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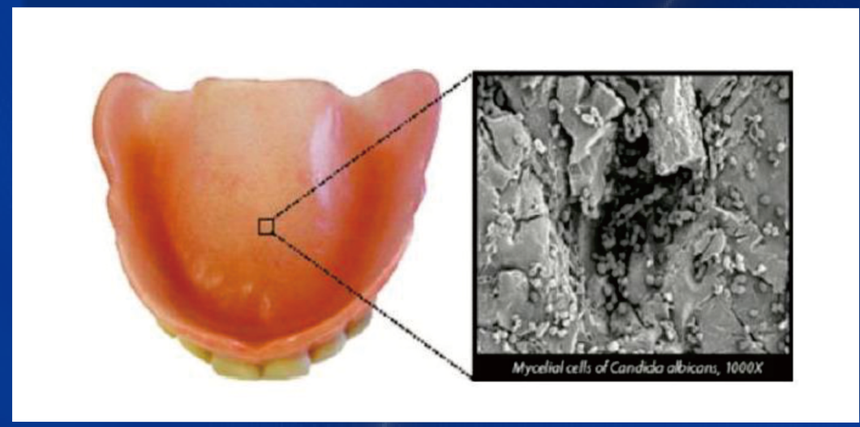
Indonesian Journal of Prosthodontics

Biannual: June and December

Vol. 4 No. 2 - December 2023



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Indonesian Prosthodontist Society

pISSN : 2723-0880

eISSN : 2723-0899

Indonesian Journal of Prosthodontics

This biannually journal is a official publication of Indonesian Prosthodontist Association/
Ikatan Prostodontis Indonesia (**Iprosi**)

Indonesian Journal of Prosthodontics December 2023 Volume 4 Number 2 Page 75-176

Contents

Scanning electron microscopy imaging to assess bone implant contact enhancement after immediate bioactive compound placement

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ABSTRACT
Along with the increasing use of implant-supported dentures, the use of biomaterials to accelerate the process of new bone formation is favorable. Chlorella vulgaris is a natural product that contains elements of calcium, minerals, and vitamin D acting in mineralizing bones and teeth. In addition, the content of flavonoids and phenols in Chlorella vulgaris that are applied topically can inhibit TNF-α therefore inducing bone healing. This study aims to assess the effect of bioactive material on bone implant contact (BIC) by using SEM imaging. Nine Landrace pigs were used in this study and surgical procedures were performed in the mandible. Chlorella vulgaris extract gel was placed in the left socket and without gel in the right socket, afterward followed by titanium implant placement. Both treatments were carried out in the same way, then three pigs were observed per one time period, namely the 30th, 60th, and 90th days by using SEM test. The BIC of the sample showed the greatest at day 90th after application of gel and implant placement. It is concluded that the use of bioactive material, gel extract Chlorella vulgaris 15%, can stimulate the osseointegration better, and improve the BIC percentage.
Keywords: osseointegration, biomaterial, bone implant contact

INTRODUCTION

The healing process in the implant system is similar to bone healing in general. At first, the blood gets between the apparatus and the bone, and then a blood clot form. Blood clots are transformed by phagocytic cells, such as polymorphonuclear leukocytes, lymphoid cells, and macrophages. The level of phagocyte activity peaked during the time between days 1 and 3 after surgery. At this time, the prosthesis is attached to the apparatus and with stimulation, bone remodeling occurs. Calcification of the Haversian bone becomes dense and homogeneous. Occlusal pressure stimulates the surrounding bone. With remodeling, the osseointegrated apparatus can retain masticatory function.[1]

Bone formation begins at the implant surface in response to surface physicochemical properties, referred to as contact osteogenesis. The use of natural materials that are considered to have minimal toxicity is needed to assist the osseointegration process. The use of 15% Chlorella vulgaris extract gel as a bioactive ingredient that is injected into the socket before implant placement can stimulate the growth and development of fibroblasts and has antipreteolytic properties and stimulates tissue formation.[2,3]

The active components in Chlorella vulgaris extract include chlorellin (anti-inflammatory), chlorella growth factor (CGF), an extract consisting of various substances including essential amino acids, peptides, proteins, vitamins, sugars, and nucleic acids. In addition, there are other ingredients of Chlorella vulgaris including carotenoids (antioxidant compounds), chlorophyll, and phycobilin (complex protein pigments found only in phytoplankton).[3–6]

In order to assess the effectiveness of the natural biomaterial compound which refer to Chlorella vulgaris extract, bone to implant contact (BIC) imaging is considered to become one of many ways to evaluate this study. There are several methods which can be used to evaluate the degree of osseointegration, by using invasive or non-invasive methods.[7] However there are limitations for each methods besides of the advantages has given. The most commonly and frequently technique being used is a micro-CT instrumentation, while the information has acquired by using 2D imaging methods which is histologycal or refered as back scattered electron SEM (BSE-SEM) and secondary electron SEM (SE-SEM).[2,7] SEM as a part of micro-CT test instrument has some advantages in assessing local variations within tissue mineraliation and could be scanning rapidly. The resolution of the imaging conducted from SEM has been improved and gives high resolution of the bone and implant interface.[8]

The presence of various active components in the Chlorella vulgaris extract which is considered capable of assisting the process of new bone formation after implant placement which assess by imaging of BIC using SEM test, thus became the purpose of writing this research report.

METHODS

Preparation of Chlorella vulgaris extract gel

Chlorella vulgaris extract filtrate through maceration technique in the form of a powder prepara-

DOI: 10.46934/ijp.v4i2.238

ration which will then be made into a gel preparation. Mixing 10 g of Chlorella vulgaris extract, propylene glycol, glycerol, methylparaben, NaCMC, and aquades to form a Chlorella vulgaris gel with a concentration of 15%. Furthermore, in vitro tests were carried out to assess the gel formulation so that it was ready to be applied.

Experimental animal treatment

The study was conducted on 9 Landrace pigs that had been adapted before treatment. The surgical procedure was performed after administration of inhalation and induction anesthesia. Placement of implants between the canine region and mandibular left and right premolars was performed on each experimental animal. After the final drilling, the sample is irrigated using saline and the socket is then dried. Next, 2 mL of 15% Chlorella vulgaris extract gel was injected into the mandibular left socket sample and the titanium implant was inserted. In the right mandibular socket, a titanium implant was inserted without Chlorella vulgaris extract gel. Both treatments were carried out in the same way on 9 pigs, then 3 pigs were observed per 1 time period, namely the 30th, 60th, and 90th days.

Preparation of gel

Taking bone tissue segments with an implant in the middle with a size of 2x1 cm. The implant preparation was cleaned with 10% formaldehyde solution for 10 minutes, then dehydrated with 70% ethanol, and then dried or vacuumed. The bone around the implant was cut with a micromotor to 2 mm at the implant margin. Bone and surrounding tissue are prepared for further cutting using a microtome at half the diameter of the implant so that it is divided into 2 parts.

The implant-embedded parts were prepared for analysis using a SEM test kit (Tescam VEGA 3, Germany) for surface morphology assessment. Observation of the preparation was done by looking at the bone-implant to contact or BIC formed. Observations were made with magnification of 100x, 1200x, and 2000x.

RESULT

Descriptive analysis of the sample describes the mean, range, and standard deviation of the amount of BIC formed in landrace male pigs after implantation of either injected extract gel Chlorella vulgaris 15% or without Chlorella vulgaris extract gel. A significant increase (P<0.05) in the BIC value in the treatment group with the BIC value day 30 of 13.79%, day 60 of 16.14%, and day 90 of 18.39% (Fig.1 & 2).

There was a significant difference between the control group not added with Chlorella vulgaris extract gel and the treatment group added with 15% Chlorella vulgaris extract gel on day 90 (P<0.05) (Table 1, Fig.3 & 4).

Table 1 The BIC value of 15% chlorella vulgaris extract gel

Group	30th	60th	90th	P value
Treatment	13.79	16.14	18.39	0.002**
Control	11.97	14.39	16.87	0.000*

* Repeated ANOVA, p value < 0.05; Significant **Friedman test p < 0.05; Significant

From the results of the SEM test on implants based on the day of observation, it was shown that there was an increase in the formation of new bone attachments with the interface distance between the bone and implants getting smaller based on the time period. This can be seen in the calculation of the BIC value with the increasing value along with the length of the observation period using SEM test with magnifications of 40x, 100x, and 1200x.

DISCUSSION

Micrometre scale technique which had been used in this study was SEM method. This method has several advantages such as using 2D imaging,

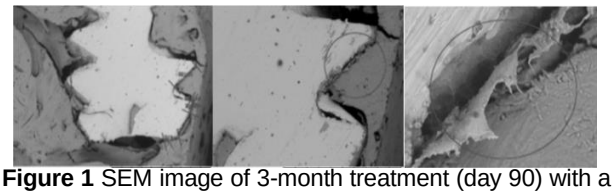

Figure 1 SEM image of 3-month treatment (day 90) with a BIC value of 18.39%

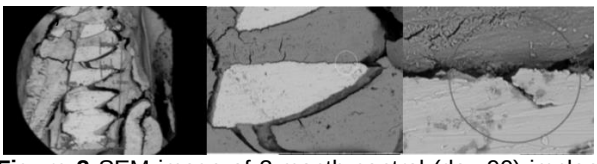

Figure 2 SEM image of 3-month control (day 90) implant with a BIC value of 16.85%

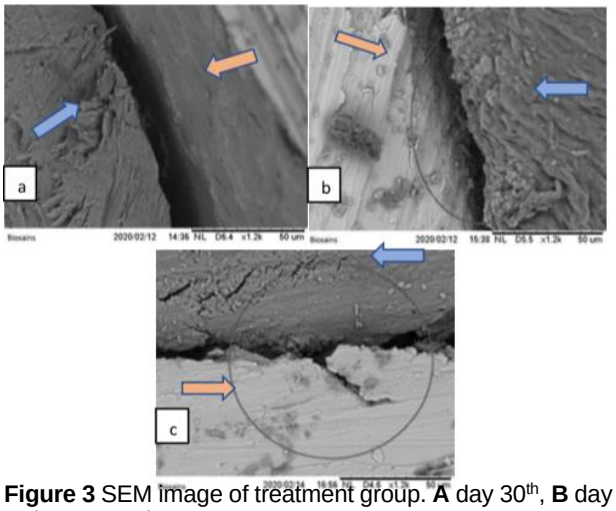

Figure 3 SEM image of treatment group. **A** day 30th, **B** day 60th, **C** day 90th (orange arrow is implant, blue arrow is bone).

DOI: 10.46934/ijp.v4i2.238

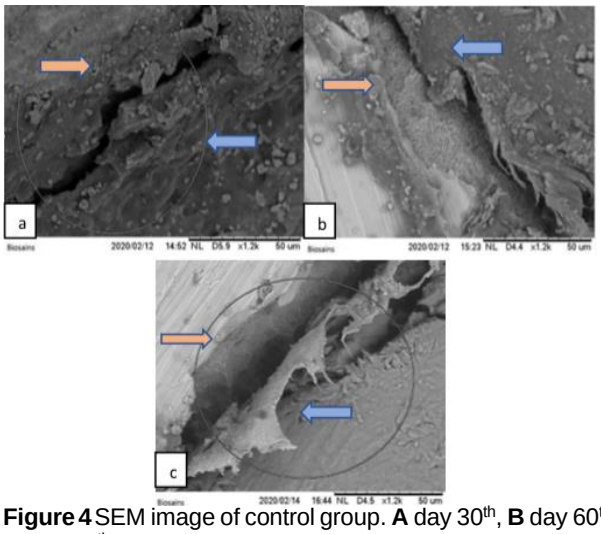

Figure 4 SEM image of control group. **A** day 30th, **B** day 60th, **C** day 90th (orange arrow is implant, blue arrow is bone)

analysis element, can be using different contrast phenomenas, low to very high spatial resolution, and high dept of field.[2] The SEM examine the rough surface of the sample preparation, and evaluate bone formation around and inside solid and porous metal implants and degradable materials, the voxels containing information of the immediate bone-implant interface are obscured by various imaging artefacts.[2,8]

Initial tissue response to implant osseointegration can be seen between titanium dental implants and new bone regeneration. Damage to both hard and soft tissues initiate the wound healing process which ultimately allows the implant to become ankylotic with bone. This condition can be seen and analyzed through BIC conducted in vivo in experimental animals. This study is an assessment of the early stage of osseointegration after implant insertion in experimental animals, by looking at the difference in BIC values between the test and reference surfaces and statistically analyzing to compare the osteogenic potential of the implant surfaces. The highest bond formation in bone and implants was characterized by an increase in trabecular density and an increase in the BIC ratio.[9-13]

After the surgical placement of the implant into the endosteal location, the traumatized bone around the implant begins the wound healing process, which starts from the inflammatory phase, the proliferative phase, to the maturation phase. A few seconds after implant placement, the entire surface of the implant is covered with a thin layer of serum protein which is a growth factor, the surface characteristics of the material have a major influence on the adhesion of the serum protein. Serum protein is associated with the activation of physiological processes of platelets (platelets) and the release of granules. This platelet degranulation releases growth factors and triggers chemotactic signals. When platelets come into contact with synthetic surfaces, they release serotonin and histamine which cause platelet aggregation and further thrombosis.[7,11]

During the proliferative phase, vascular growth occurs from the surrounding vital tissues, a process called neovascularization. In this phase, the effect of Chlorella can reduce the secretion of cytokines so that it is hoped that new tissue is more easily formed and wound healing is faster. The metabolism of local inflammatory cells, fibroblasts, progenitor cells, and other local cells creates an area of relative hypoxia in the wound area that triggers local mesenchymal cells to differentiate into fibroblasts, osteoblasts, and chondroblasts.[6,7]

Chlorella vulgaris has a myelostimulating effect through cytokine induction, interferes with the production of IFN-c, IL-1a and TNF-a, and increases the production of IL-10 and IL-6 suppress the infla-flammatory cytokine TNF-alpha and inflammatory mediators (nitric oxide) also stimulate the production of IFN-c, IL-1a, TNF-a and NK cell activity. The main component of Chlorella is chlorella growth factor (CGF), an extract consisting of a variety of substances including essential amino acids, peptides, proteins, vitamins, sugars, and nucleic acids. Activation of fibroblasts by Chlorella with the accelerated formation of granulation tissue where the granulation tissue consists of connective tissue and fibroblasts, new blood vessels (angiogenesis), and inflammatory cells. The CGF stimulates increased growth and development of fibroblasts. The extracellular matrix is created by these cells and eventually, a fibro-cartilaginous callus is formed which turns into a bone callus. Early immature bones are called woven bones.[3.6]

One of the antibiotics contained in Chlorella is called Chlorellin and acts as a new anti-inflammamatory agent from natural sources with fewer side effects. Meanwhile, fibrin nets have formed that cover the wound, and the infiltration of leukocyte cells into the wound area is carried out first by neutrophils. Its migration is influenced by cytokines such as IL-1 and TNF alpha. In this phase, the effect of Chlorella triggers an increase in the levels of several cytokines that are useful in increasing leukocyte activity. Chlorella's anti-inflammatory effects include inhibiting the production of IL-5 by mast cells, inhibiting GM-CSF cytokines, and inhibiting angiotensin I-converting enzyme (ACE).[3]

Inflammation is an important host defense mechanism and is characterized by complex interac-

DOI: 10.46934/ijp.v4i2.238

tions between inflammatory mediators and inflammatory cells. When the tissue is inflamed, fibroblasts will immediately migrate towards the wound, proliferate and produce a collagen matrix to repair damaged tissue. Activation of fibroblasts by Chlorella with accelerated formation of granulation tissue where the granulation tissue consists of connective tissue and fibroblasts, new blood vessels (angiogenesis), and inflammatory cells. CGF stimulates increased growth and development of fibroblasts. Chlorella also stimulates the activity of T-cells and macrophages by increasing interferon levels, thereby increasing the immune system's ability to fight bacteria, viruses, chemicals, or foreign proteins.[3,6,14,15]

The remodeling process begins at week 12 and the strength of the interface between implant and bone increases after 0-12 weeks of placement, this implant is related to the amount of bone surrounding the bone. In the treatment group or implants previously injected with 15% Chlorella vulgaris as a bioactive ingredient into the socket, the mean BIC value was higher than the group without extract.

In weeks 2-4, namely the stage of cell proliferation and callus formation, osteoblast cell deposition occurs on both implant and bone surfaces. At this stage the BIC value on days 30-60 increased in the treatment group, indicating that Chlorella vulgaris can trigger local acceleration of bone formation, early expression of growth factors, bone differentiation, and osteogenesis which accelerates the formation of young bone or woven bone. control group. The flavonoids and CGF present in Chlorella vulgaris stimulate the acceleration of angiogenesis and bone formation around the implant. CGF induces bone morphogenetic protein and osteogenetic synergy occurs.[11,12]

It is concluded that application of 15% Chlorella vulgaris extract gel resulted in better adhesion between bone and titanium implant surface which was indicated by a higher BIC value on day 90 and accelerated the osseointegration process observed by SEM test.

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DOI: 10.46934/ijp.v4i2.238

Marginal fit comparison of conventional and CAD/CAM techniques of PMMA temporary crown

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ABSTRACT
Despite the weakness of PMMA as a temporary crown, this material has a high fracture resistance. PMMA can be used for a long time as a temporary and it can replace teeth loss. The marginal fit of the temporary crown must be as precise as that of the definitive crown to prevent irritation of the pulp tissue, inflammation of the periodontal tissues, and also produce an esthetic result. CAD/CAM temporary crown made of PMMA is a new concept in dentistry so it still needs to be investigated regarding the marginal gap in considering the use of conventional PMMA temporary crown. The objective is to review the comparison of the marginal gap of temporary crowns made from PMMA with CAD/CAM technology against conventional method. It is concluded that temporary crowns manufactured by CAD/CAM method produces a better marginal fit than the conventional method. Polymerization shrinkage is one of the causes of dimensional changes that cause a marginal gap.
Keywords: PMMA, temporary crown, CAD/CAM, conventional, marginal fit

INTRODUCTION

Temporary crowns play an important role in fixed prosthodontic treatment, especially when long-term care is required before the final restoration is placed. According to the Glossary of Prosthodontics, provisional or interim prostheses are fixed or removable dental restorations or maxillofacial prostheses designed to improve aesthetics, stabilization on and function within a limited period of time which will later be replaced with definitive dental or maxillofacial prostheses. The purpose of temporary crowns is to protect the pulp and periodontium tissue to provide healing according to the planned emergence profile, to evaluate oral hygiene, prevent migration of neighboring teeth, improve esthetics and phonetic function as well as provide an adequate occlusal scheme and evaluate intermaxillary relationships.[1]

The most commonly used materials for fixed temporary crowns include polymethyl methacrylate (PMMA) resin, polyethyl methacrylate (PEMA) resin, polyvinyl methacrylate resin, bis-acryl composite resin, and visible light-cured urethane dimethacrylates. The choice of temporary crown material depends on the mechanical properties, physical properties, ease of use, biocompatibility in intraoral that is chemical reactions due to monomer residues and exothermic reactions.[1]

Although PMMA has weaknesses in poor color stability, high shrinkage during polymerization, marginal discrepancy, easy to absorb liquids, unpleasant odor, but this material is more economical and has high fracture resistance so that it can be used for a long time or used in cases to replace a large number of teeth. This is what makes PMMA used for decades until now.[2–4]

The marginal fit of a temporary crown must be as precise as a definitive crown to prevent irritation of the pulp tissue and inflammation of the periodontal tissues and also produce an aesthetic result.[5] Minimizing marginal discrepancies results in a better biological response, especially for the soft tissues around the restoration and minimizes sensitivity and caries. Secondary to a clinically acceptable marginal opening of less than 120 µm is recommended. Material properties, such as shrinkage polymerization, thermal expansion and contraction, water sorption and plastic deformation play a role in dimensional stability that affects the marginal gap. The marginal gap in temporary crowns can increase when there are thermal changes and repeated occlusal loads in the oral cavity.[6] Marginal fit is a factor that influences the long-term success of all restorations. Optimal marginal fit results in better periodontal tissue and minimizes cement dissolution.[7]

In the fabrication of temporary crowns there is a direct technique where in this stage the teeth and gingival tissue are prepared directly and eliminate laboratory procedures. This technique is the most frequently used technique with the advantages of time saving, simpler, more precise, less expensive procedure but the disadvantages of presence of saliva, limited visibility, inadequate access, tissue trauma from the resin polymerization and poor marginal adaptation. Furthermore, the indirect technique where the temporary crown is made outside the oral cavity using the impressions of the pre-

DOI: 10.46934/ijp.v4i2.239

pared teeth, in this technique the monomer is free and heat during polymerization does not come into direct contact with the patient's teeth and gums so as to avoid injury to the patient's soft tissues and teeth, with this technique. This results in better marginal adaptation.[1]

Making a temporary artificial crown with the direct method requires waxing on the diagnostic model. In making this diagnostic model requires extra meetings and adds time and costs to the patient.[8] To overcome the shortcomings of the direct technique, the indirect CAD/CAM technique emerged which aims to overcome the shortcomings of the previous technique. Computer aided design and computer aided manufacture (CAD/CAM) are new methods introduced in the manufacture of temporary dentures which can be subtractive or milling and additive (3D printing) methods. The CAD/CAM method allows the temporary denture to polymerize well thereby improving mechanical properties, reducing discoloration and increasing precision.[6] The indirect technique can prevent pulp irritation due to exothermic reactions and residual monomer polymerization of the direct method. Digital technology provides precision and accuracy in the manufacture of definitive and temporary crowns.[7] CAD/CAM technology shortens the time and makes it easier to manufacture temporary crowns. The clinical goal of temporary artificial crowns is minimal marginal gap, can protect teeth, prevent caries and maintain healthy gingival tissue.[8]

The indirect fabrication technique has a better marginal fit than the direct technique for PMMA materials. Along with the development of technology, a method of indirect temporary crown fabrication has emerged using CAD/CAM technology. The CAD/CAM temporary crown made of PMMA is a new concept in dentistry, so it still needs to be investigated regarding the marginal gap in considering the use of conventional PMMA artificial crown. Currently, there are several journals regarding the marginal gap of temporary crowns fabricated with CAD/CAM technology but the results are varied.

This paper aims to systematically compare the marginal gap of the PMMA temporary crown fabrication technique with the CAD/CAM technology against conventional methods.

LITERATURE STUDIES

This paper is a scoping review that summarizes and shows the results of existing research on a particular topic or field of science. The steps taken in the preparation of this scoping review are determining study questions, determining the appropriate type of research, conducting study selection, collecting data in a chart, and compiling and compiling a summary as well as a report on the results of the study. This scoping review is based on the staging framework from Arksey[7] and the Preferred Reporting Items for Systematic Review Extension for Scoping Review (PRISMA-ScR) guidelines.[8]

The research question in this scoping review is "Does PMMA temporary crowns made with CAD/CAM technology compared to conventional produce better marginal fit?".

This research is based on the PICO model, (P) conventional PMMA temporary crowns are prone to poor marginal fit, (I) PMMA temporary crowns made using CAD/CAM, (C) temporary crowns made of PMMA with conventional techniques, (O) marginal fit of PMMA temporary crown.

Data collection through the Pubmed and EBSCO data search engines on November 24, 2021, with the search strategy in Table 1. The inclusion and exclusion criteria used are as shown in Table 2.

This scoping review is based on Arksey's step, starting with identifying research question, "Does conventional temporary crowns compared to CAD/CAM technology produce a better marginal fit?". Next, identify articles that are relevant to searching and collecting data through Pubmed and EBSCO data search engines on November 24, 2021 where

Table 1 Search strategy

Source	Keyword	Total
PubMed	"CAD/CAM" AND "provisional" OR "interim" AND "marginal fit" OR "marginal discrepancy" OR "marginal integrity" AND "PMMA"	18
EBSCO	"CAD/CAM" AND "provisional" OR "interim" AND "marginal fit" AND "PMMA" published date 20150101-20211131	36

Table 2 Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication	Januari 2015–November 2021	Before Januari 2015
Language	English	Except english.
Concept	Marginal fit temporary crown made from CAD/CAM & conventional PMMA fabrication.	Temporary crown based on Bys-Acryl
Design	Randomized clinical trial, Experimental laboratorium	Clinical report, systematic review & meta-analyses, literature review
Full Text	Available	Not Available

DOI: 10.46934/ijp.v4i2.239

54 articles were obtained, then eliminating 2 duplicate articles followed by selecting articles according to the inclusion and exclusion criteria in Table 2. Furthermore, compiling, evaluating and reporting the results of the article.[9]

RESULTS

Search results using keywords on PubMed yielded 18 results and an EBSCO search yielded 36 results. Based on a search of each of the results, the total results obtained were 54 articles. Based on the search for titles and abstracts of the 54 articles, 2 duplications were excluded. A full text search was carried out from all the remaining findings. The title, abstract and full text are read thoroughly, then adjusted according to the inclusion and exclusion criteria that have been set. Then, 38 findings were eliminated according to the established inclusion and exclusion criteria and after reading, 9 articles were eliminated because the titles and abstracts did not match the inclusion criteria. Finally, 5 search results were obtained which were included in this scoping review.

The flow of the literature search that is included in the scoping review is shown in Fig.1. The results of the literature review included in the scoping review are shown in table 3.

DISCUSSION

Factors that cause marginal discrepancy in temporary artificial crowns are material type, fabrication process, thermal and mechanical aging and duration of use when functioning. In the research of Angwarawong et al, it was shown that differrences in materials and thermomechanical aging processes gave a significant marginal gap effect.[6] Polymerization shrinkage is one of the causes of dimensional changes that cause a marginal gap. This problem arises more in PMMA material than Bis-acryl which has a filler so that it results in lower shrinkage. Polymerization shrinkage is lower in the manufacture of temporary artificial crowns with CAD/CAM because PMMA blocks have gone through a prepolymerized process according to the manufacturer's regulations during fabrication and the 3D print method goes through a better polymerization process because they are polymerized layer by layer. This causes the CAD/CAM temporary artificial crown to have a lower marginal gap than the conventional method.[6] Mai et al reported that the marginal gap of 3D printing is comparable to the milling method and significantly better than conventional.[11]

Thermal and mechanical aging gave significant marginal gap changes in the CAD/CAM and conventional temporary crown groups. Thermomechanical aging affects the marginal gap in a number of ways including polymerizazion stresses, residual unreacted monomer, voids in resin and water sorption. Changes in temperature cause contraction and expansion, especially in the thin margin area, can cause cracks in weak or porous areas that cause an increase in the marginal gap. Humid conditions and the use of water in the aging simulation can be absorbed and disrupt the polymer chain causing a decrease in resin strength and dissolving the residual monomer thereby increasing the porosity in the marginal area. Apply occlusal pressure puts stress on the temporary crown and when the stress exceeds the elastic limit of the material it can cause distortion of the marginal area.[6]

PMMA autopolymerizing generally has more voids and unreacted monomer residues so that it has a higher water sorbption than bis-acryl, CAD/CAM milling and CAD/CAM 3D printing. Research by Angwarawong et al. reported that PMMA who had received stress simulation in an oral cavity simulation had a significant increase in the marginal gap compared to other groups.[6]

The vertical discrepancy is clinically very important because it will expose the luting cement and tooth structure to the oral environment while the horizontal discrepancy also has a clinical effect because it will produce a step defect between the tooth and the crown which makes it difficult for the patient to clean the area so that it becomes the cause of plaque accumulation.[6]

It is necessary to increase the default space on the CAD/CAM crown due to the surface roughness of the stereolithic impression. Although the ideal cement space is between 20-40 µm, in Yong et al study, the setting was 60 µm for Cerec crowns and 120 µm for E4D crowns, so this setting affects the dye penetration results where E4D has the highest value. Thermocycling and occlusal loading have been shown to increase the size of the marginal gap in temporary crown restorations. In this study, it was found that the vertical discrepancy of the facial portion of the Caulk transient crown was due to the polymerization of PPMA undergoing shrinkage in air.[8] According to the study of Ogawa et al, it was shown that marginal adaptation was significantly increased when the interim PMMA material was polymerized in water at 20-30°C.[12] Research of Peng et al. also used the default 60 µm setting in the CAD/CAM method to create a cementation chamber with die spacers as well to compensate for polymerization shrinkage of the resin.[7]

DOI: 10.46934/ijp.v4i2.239

Table 3 Marginal fit comparison of conventional and CAD/CAM techniques PMMA temporary crown

Author;Year; Design	Research Purposes	Subject	Result	Conclusion
Angwarawong et al.[6] (2020) *In vitro*	Evaluating the marginal gap of temporary artificial crowns made from different materials and techniques before & after receiving simulated oral stress.	10 specimens per group 2 Conventional resins: PMMA (Unifast Trade) & Bis-Acryl (Protemp 4) 2 CAD/CAM: Milling PMMA (Brylic Solid) & 3D printing BisAcryl (Freeprint temp) All temporary crowns were thermocyled 5000 cycled & 100,000 cycled occlusal load 100 N with 5 mm metal ball in the central fossa representing 6 months of the oral environment.	• The type of material and the aging process have a significant effect on marginal gap (p<0.001) • Conventional group had a significant marginal gap change compared to the CAD/CAM group both before and after the aging process (p<0.01) • All groups had an increase in the marginal gap after aging (P<0.001) • The largest increase in the marginal gap in the Conventional PMMA group	• Type of material & the aging process affected significantly marginal gap changes in all temporary artificial crown groups • CAD/CAM group had better marginal gap adaptation than conventional both before & after the aging process. • The marginal gap of all groups after the aging simulation are still clinically acceptable (<120 µm)
Penate et al.[5] (2015) *In vitro*	Compare marginal fit & fracture strength of conventional crown (direct tech) (Structure 3, Trim, Duralay) with the CAD/CAM (Telio CAD)	60 specimens each from Conventional group. The temporary crowns were stored for 24 hours at 37°C before thermocycling. Marginal fit was evaluated at 6 points before and after thermocycling 2500 and 5000 cycles with a stereomicroscope (x40; Olympus Corp)	• Conventional PMMA group had the largest marginal discrepancy compared to other groups before thermocycling (93.7) & after 5000 cycles of thermocycling (169.7). All groups experienced an increase in marginal gap after thermocycling process but did not differ significantly (p>0.001)	• The conventional PMMA Duralay group had the largest gap margin before the thermocyling process compared to other CAD/CAM groups but after 5000 cycles it was not significantly different from the other groups.
Yong et al.[8] (2016) *In vitro*	Evaluating the marginal integrity of temporary crowns made from CAD/CAM and conventional PMMA	Dentoform model of the left second premolar prepared (1 mm axial, 2 mm occlusal and subgingival chamfer margin) for the ceramic crown was scanned with (Lava COS, 3M ESPE) and 60 resin dies were printed. Interim created: 15 Telio CAD-CEREC (milling system), 15 Paradigm MZ100-E4D (milling system), 15 autopolimerisasi resin (Caulk Dentsply), 15 autopolimerisasi resin Jet (Lang Dental). Cementation tempgrip 17.8 N, thermocycled 100 cycles, soaked 0.5% fuschin acid for 24 hours. The marginal gap is examined with a microscope (4x)	• Marginal vertical gap in conventional temporary crown is larger than CAD/CAM (p = 0.06) • Marginal horizontal gap in the temporary crown was not significantly different between groups (p=0.276)	• Significantly less vertical marginal difference in temporary crowns made with CAD/CAM compared to Conventional • Temporary crowns made from Caulk have the largest mean marginal discrepancy on the facial and lingual surfaces and the smallest mean by Paradigm MZ100-E4D.
Peng et al[7] (2020) *In vitro*	Evaluating the internal fit and marginal discrepancy of temporary artificial crowns from various manufacturing methods.	Tooth 36 dentoform was prepared for a ceramic crown, scanned and printed for 48 specimens: • 16 Autopolymerized PMMA (Jet) direct • 16 CAD/CAM Milling PMMA (Zcad Temp fix) indirect • 16 CAD/CAM 3D print Methacrylic oligomers (Nextdent) indirect	• In the PVS evaluation, the marginal discrepancy of the autopolymerized PMMA group was statistically significantly higher than that of the CAD/CAM milling and 3D print groups (p<0.05) • There was no significant difference in the CAD/CAM Milling & 3D printing groups (p>0.05)	Temporary crowns made by the digital method has a smaller marginal discrepancy than the conventional method.
Lee et al[10] (2017) *In vitro*	Evaluate marginal gap of temporary crowns produced by CAD/CAM Milling and 3D printing.	Master model (stainless steel) is duplicated with the VPS to create a working model. The working model is scanned, STL data is served for 10 CAD/CAM Milling (VIPI Block), 10 CAD/CAM 3D printing (Stratasys), 10 CAD/CAM 3D printing (Dentis). Marginal gap evaluation with silicone.	All groups experienced marginal discrepancy CAD/CAM Milling discrepancy of 119.1±54.8 µ, CAD/CAM 3D printing (Stratasys) 115.6±68.8 µ CAD/CAM 3D printing (Dentis) 64,3±30 µ. There were no significant differences and all groups were clinically acceptable (< 120 µ)	Method of making temporary crowns with digital additive CAD/CAM (3D printing) technology produces a better marginal gap than subtractive (milling). The 3D printing method can be considered to be applied to the manufacture of more complex prostheses.

DOI: 10.46934/ijp.v4i2.239

The use of silicone impression as a material to evaluate the marginal gap and internal fit gives greater results than the CT scan technique. Kim et al study found 1.5x greater results and Peng et al also found 3x greater results than CT scan.[7] Abdullah et al evaluated the marginal gap for temporary artificial crowns using lightbody silicone material as cementation material and found a material gap variation of 47-193 µm. The results of the cementation thickness depend on the cementation material used, namely based on the composition, viscosity and flowability of the material.[7]

Peng et al study stated that the largest marginal gap was in the direct method PMMA autopolymerization group. CAD/CAM milling and 3D printing groups had no significant differences. The use of CAD/CAM for the manufacture of temporary crowns has better adaptation than conventional.[7]

The disadvantage CAD/CAM milling method is that a lot of material wasted and the resulting prosthesis is not smooth because it has micro hollows due to the influence of the diameter of the cutter bur used which can result in poor marginal gaps. In contrast to additive CAD/CAM which is more precise in results however, in sharp, protrusive and undercut conditions it is more difficult to reproduce with 3D printing.[10]

Minimizing marginal discrepancies results a better biologic response especially for the soft tissue surrounding the restoration, minimizing tooth sensitivity and secondary caries. Clinically acceptable marginal area opening is recommended to be less than 120 µm. Material properties, such as shrinkage polymerization, thermal expansion and contraction, water sorption and plastic deformation play a role in dimensional stability that affects the marginal gap. The marginal gap in the temporary crown can increase when there are thermal changes and repeated occlusal loads in the oral cavity.[6]

It is concluded that CAD/CAM method to manufacture temporary crowns produces a better marginal fit than the conventional method. Polymerization shrinkage is one of the causes of dimensional changes that cause a marginal gap. Polymerization shrinkage is lower in the manufacture of temporary artificial crowns with CAD/CAM technology because PMMA blocks have gone through a prepolymerized process according to the manufacturer's regulations during fabrication and the 3D print method goes through a better polymerization process because they are polymerized layer by layer.

There are several weaknesses in scoping review. The studies that reviewed all were in vitro studies so they did not simulate the actual conditions of the oral cavity such as the direction and magnitude of masticatory forces, temperature degradation of the material due to enzymes in saliva, pH, oral hygiene as well as diet and masticatory function. In CAD/CAM studies on artificial crowns made from PMMA, it is still relatively new so that the results obtained are not many and are still in the form of laboratory research, so further studies are needed to get more accurate results.

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Evaluation of treatment on unilateral cleft lip and palate complete dextra to the quality of life: 4-year follow-up

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ABSTRACT
Treatment for the patient with cleft lip and palate (CLP) requires an interdisciplinary team concerned with improving the patient's quality of life. This case evaluates the influence of comprehensive therapy on unilateral CLP complete dextra within a 4-year follow-up. A 4-days-old female patient visited a government hospital in Bandung after being referred to a pediatric clinic in the same hospital. The patient was born at 3.2 kg weight with no underlying medical conditions or syndromes. Intraoral examination revealed cleft soft and hard palate and separated alveolar segment. Extraoral examination revealed cleft lip unilateral dextra and shortened columella. The patient underwent comprehensive therapy including presurgical NAM (PNAM), labioplasty, nasoalveolar molding (NAM), veloplasty, speech therapy, and palatoplasty. It is concluded that early treatment of PNAM reduces the severity of the orofacial deformity, induced the reposition of soft & hard tissue and there's an improvement in intelligibility and production of pharyngeal sounds and velopharyngeal closure when using intravelar veloplasty in palatal repair along with NAM. In the fourth year of life, the patient has capable on communicates with intelligibility pronounce with relative adequate arch.
Keywords: unilateral cleft lip and palate complete dextra, nasoalveolar molding, intravelar veloplasty, comprehensive treatment

INTRODUCTION

Cleft lip-and-palate (CLP) is considered the most common congenital craniofacial birth anomalies in different populations. According to the literature based it has a multifactorial etiology, comprising both genetic and environmental factors. And the relative risk of CLP including environmental influence (smoking, alcohol use, drugs, and dietary factors) will be useful for the development of future preventive measures.[1,3,10] The presence of CLP introduces feeding difficulties, concerns regarding speech development, and the possibility of impaired facial growth. Children with cleft anomalies may experience a multitude of physical and developmental challenges. There also may be psychosocial and emotional concerns for the patients and their families. As such, comprehensive care for the patient with cleft lip and or palate requires an interdisciplinary team.[1,3] The guidelines for team care outlined by the Government Hospital in West Java Indonesia recommend team members that may include oral maxillofacial surgery, prosthodontics, orthodontics, pediatrics, pediatric dentistry, otolaryngology-head and neck surgery, plastic surgery, anesthesiology, audiology, genetics, neurosurgery, ophthalmology, psychology, psychiatry, and speech-language pathology. Management of patients suffering from CLP can start early at infancy with treatment goals of lip segments approximation, nostrils symmetry achievement, increase columellar length, and alveolar segments alignment. In other words, the aim at infancy is to help the surgeons to achieve better surgical result by decreasing the severity of the cleft defect.[10]

The early treatment of CLP is nasoalveolar molding (NAM) therapy, that may be successfully employed in the early management of both unilateral and bilateral cleft anomalies in newborns.[8] Studies have shown that when instituted at 1 week of age and continued 3-4 months, NAM is effective in approximating the cleft as well as improving the nasal deformity. Patients undergoing NAM treatment experienced improved nasal alar symmetry, columella lengthening, and nasal tip projection.[1] Performing intravelar veloplasty (IVV) along with NAM in primarily repaired palates was believed to gain the functional repair of the palate. Early repair of cleft palate yields the best results in regard to adequate velar port closure, less hypernasality of speech, and better development of speech articulation. The velum is known to have a great role in producing intraoral pressure and thereby producing certain sounds by its movement against and down the pharyngeal musculature and maintenance of nasopharyngeal closure during feeding. Adequate velar port closure is essential for the balance of oronasal resonance during speech production.[4] Previous anatomic studies of the palatal musculature concluded IVV would decrease the incidence of post palatoplasty velopharyngeal insufficiency (VPI).[5] So,

DOI: 10.46934/ijp.v4i2.213

IVV significantly improves velopharyngeal port closure and speech production later in life.[3]

In this case patient experienced a complete unilateral CLP. The objective of cleft lip repair is to approximate the medial and lateral lip elements with preservation of natural landmarks, align a functional concentric orbicularis, and to establish symmetry and proportionality.[1] From the beginning, the patient's planned for undergone 2 stage closure with soft palate closure at 12 months of age and hard palate closure will be planning at approximately 5 years old. The 2 stage palate repair with delayed hard palate closure was chosen for the patient to mitigate the risk of growth interference. By performing a veloplasty first, the hard palate is encouraged to narrow as it facilitates normal midfacial growth.[1]

CASE

A 4-day-old female patient visited a government hospital in Bandung after being referred to a pediadiatric clinic in the same hospital. The patient is the firstborn with unremarkable family history. The baby was born after a full-term pregnancy at 3.2 kg weight with no underlying medical conditions or syndromes. Intraoral examination revealed cleft soft and hard palate and separated alveolar segment. There is an external and upward rotation of the medial segment of the premaxilla and an internal and posterior rotation of the lateral segment. Extraoral examination revealed cleft lip unilateral dextra and shortened columella. The patient underwent comprehensive therapy including NAM stage 1, labioplasty, NAM stage 2, IVV, speech therapy, and palatoplasty (Fig.1).

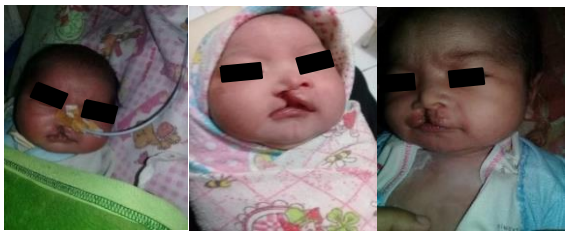

Figure 1 The 4-day-old patient

MANAGEMENT

A comprehensive treatment was initially started with NAM therapy. The first phase was to take an impression prior to fabricating the plate under pediatric supervision. The impression is obtained with the infant fully awake and without any anesthesia. The infant was held to prevent the possible aspiration of regurgitated stomach contents and also helped to lay in the upright position during taking an impression to avoid any aspiration of the materials.

Care is taken to ensure that the material has registered the border regions of the maxilla and premaxilla as well as the cleft region. The infant should be able to cry during the impression-making (Fig.2) procedure. If no crying is heard, the airway is blocked. At our institution, all impressions of clefts in infants are made in the hospital setting with a pediatrician present as part of the impression team. The hospital setting also allows a rapid response by an airway team should there be an airway emergency.

Figure 2 An elastomer impression

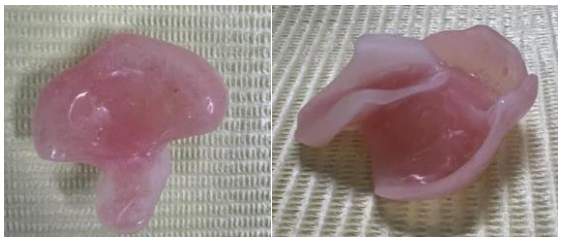

Figure 3 NAM appliance

The NAM appliance was fabricated using heat-cured polymethyl methacrylate resin. Any part that makes contact with the defect area is the anatomic part and the other side is the mechanical part. After initially inserting the oral molding appliance, the baby must be observed for several minutes while the clinician stabilizes the appliances. The infant must be able to easily suckle without gagging or struggling. Parental caring for the treatment is immensely fundamental. The parents were instructed on the use of the plate for 24 hours despite cleaning the appliances in between. They were also counseled regarding potential complications and were shown pictures to enable them to spot rashes early. They were also shown how to clean the mouth and peri-oral area post-feeding (Fig.3).

To achieve the desired movement, the acrylic is selective removed from the region into which one desires the alveolar bone to move. These minor adjustments are made weekly. The ultimate goal of the addition of materials and selective grinding is to reduce the size of the cleft gap and to have the two segments of alveolus contact with the configuration of a proper maxillary alveolar arch form. On the second visit, an extraoral retentive button is built at the site of the cleft in the lip. This retentive

DOI: 10.46934/ijp.v4i2.213

button serves to facilitate both the positive seating of the appliance to the palatal tissue and to secure the retentive lip tapes and elastic bands. Proper lip taping between appointments is crucial if the appliance is to be maximally effective. The tape will serve to help retain the appliance and allows the soft tissues of the lip and nasal base regions to become more properly oriented as the nasal stent is developed. A lip tapping force in conjunction with a molding plate yields a controlled movement of the alveolar segments and also serves to improve the alignment of the nasal base region by bringing the columella toward the midsagittal plane (Fig.4). Lip tapping also improves the symmetry of the nostril apertures.[7]

Figure 4 Patient underwent lip tapping

In this report, a nasal stent was incorporated into the molding plate when the cleft gap has been reduced to approximately 6 mm or less (Fig.5).

Figure 5 Alveolar gap was reduced to approximately 4.5 mm

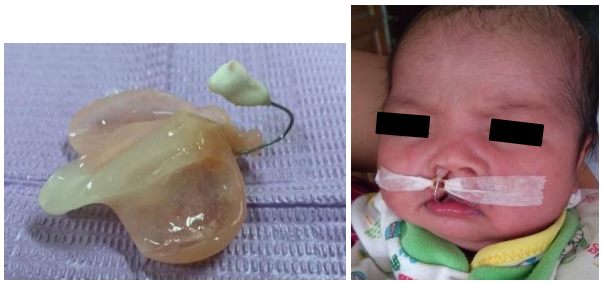

Figure 6 An incorporated nasal stent to the molding plate

The stent serves as a custom tissue expander that slowly corrects the flattening of the cleft lip nasal deformity. It also serves to bring the columella into a more midline position when the lip has been taped with the nasal stent in place. Nasal stent positioned in nostril aperture to support the dome and reposition lower nasal cartilage. The nasal stent exerts a reciprocal intraoral molding force against the alveolar segments (Fig.6).[7]

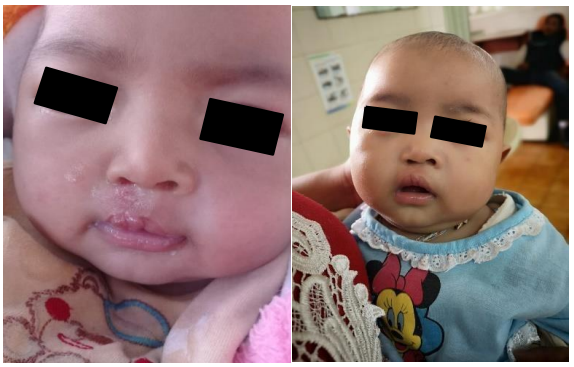

Figure 7 1-month post labioplasty

The patient underwent labioplasty on 15 weeks of age after regaining the exact improvement of the soft and hard tissue reposition. Sufficient weight according to triple ten is mandatory. Following evaluation, an impression of the intraoral cleft defect was made using an elastomeric material in an acrylic custom tray for stage two NAM appliance. The infant underwent speech therapy provided by a rehabilitation medic at 11 months of age (Fig.7).

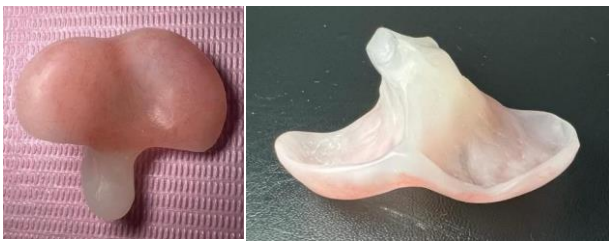

Figure 8 A stage two of NAM appliances

According to Taylor, the palate repair is performed at our institution when the infant shows evidence of phoneme speech development at approximately 11-13 months of age. Several palate-repairs surgery at our institution were held initially with IVV. IVV is the procedure of reconstruction of the levator muscle sling in cleft palate patient in order to gain velopharyngeal (VP) closure. It is achieved by detaching the levator muscles from their abnormal attachment to the hard palate and repairing them in the midline with the muscle fibers oriented more normally. The main objective of IVV surgery was to avoid the undesirable VP closure insufficiency. The term VP insufficiency refers to a structural deficit in VP spinchter. The patient underwent IVV surgery on 13 months of age (Fig.8).

As along with speech therapy the patient regularly visits the department of prosthodontics for

DOI: 10.46934/ijp.v4i2.213

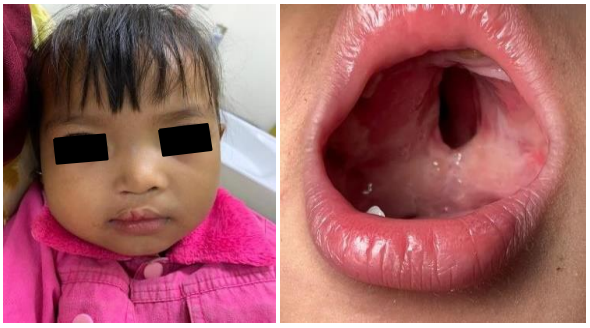

Figure 9 Four months post IVV

observation (Fig.9). Selective grinding was done to the NAM in order to reduce the size of the palate defect (Fig.10). As the years goes by, the NAM has been regularly rebuilt and also reduced. The patient was well adapted to the NAM and highly capable to chew and also swallow (Fig.11). The patient spoke in good articulation and good word spelling.

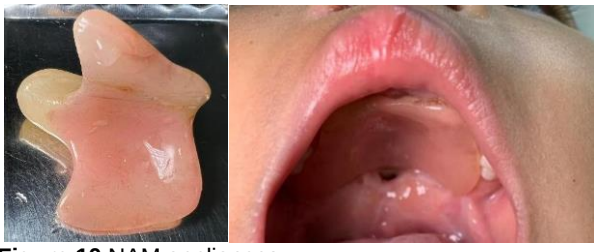

Figure 10 NAM appliances

Figure 11 A 3 years old patient

Figure 12 A 4 years old

In the fourth year of the patient's life, she's capable on communicates with intelligibility pronounce with relative adequate arch (Fig.12). The patient was managed gradually to discharge of appliance by learning to talk, sing, drink and swallow without NAM. Until today the patient is under monitoring still by the rehabilitation medic therapist to improve the pronunciation structures. At five years of age, the patient will have been planning to undergo palatoplasty surgery.

DISCUSSION

The unilateral cleft lip and palate defect will yield a less than ideal esthetic result when addressed only through a surgical correction. The basic goal of any approach to cleft lip, alveolus, and palate repair is to restore normal anatomy. Ideally, deficient tissues should be expanded and malpositioned structures should be repositioned prior to surgical correction. This provides the foundation for a less invasive surgical repair.[7] NAM serves two purposes. In addition to closing the hard tissue gaps to enable the surgeon to better close the gap, it was also hoped that the plate would help her feed and gain weight to reach the proper and safe weight to perform surgery under general anesthesia. NAM includes not only the reduction of the size of the intraoral alveolar cleft through molding the bony segments, but also the active molding and positioning of the surrounding soft tissues affected by the cleft, including the deformed soft tissues and cartilage in the cleft nose. This is accomplished through the use of a nasal stent that is based on the labial flange of a conventional oral molding plate and enters the nasal aperture. The stent provides support and gives shape to the nasal dome and alar cartilages.[7,8] The infant should be carefully monitored on a weekly basis to check the progress of the movement of the ridges and avoid a situation where there is *locking out* of the lesser segment by the posteriorly directed greater segment. When the cleft gap has been reduced to approximately 6 mm or less, a nasal stent may be added to the molding plate. The proper sequence of molding (alveolar followed by nasal) is followed to avoid the production of a *mega-nostril*. According to Latham, the first surgical procedure is usually performed between 12 and 16 weeks of age to address the defects of the entire nasolabial complex. The palate repair, if indicated, is usually performed once the infant shows evidence of phoneme speech development and occurs at approximately 11-13 months of age.[7]

The jaw and palate develop along normal lines if the soft palate is closed during infancy by means of primary veloplasty. The residual cleft in the hard palate remains. The cleft becomes narrower with

DOI: 10.46934/ijp.v4i2.213

growth of the palate without causing compression of the jaw.[9] The success of palatal repair is directly related to the adequacy of velar muscle repair. Adequate VP closure is essential for the balance of oronasal resonance during speech production. The complete VP closure occurs from the simultaneous movement of the soft palate and the lateral and posterior pharyngeal walls, which ensures the complete separation between the oral and nasal cavities during the production of oral speech sounds.[3,4] Previous anatomic studies of the palatal musculature concluded IVV would decrease the incidence of post palatoplasty VPI. VPI is highly undesirable and would lead to the appearance of characteristic symptoms such as hypernasality because there is a communication between the oral and nasal cavities, so part of the air current diverges to the nasal cavity during the production of oral speech sound.[4-6] As far as speech development is concerned, the intelligence and the temperament of the child play an important part as do family attitudes. Communicative children in a socially favorable environment will find it easier. In any case, most children are able to enter normal schools. Follow-up investigations into the comprehensibility of speech have shown that speech improved after school entry as it is true for most children. In terms of enabling the jaw and face to develop normally and facilitating the development of normal speech, the primary veloplasty is really justified and recommended for the rehabilitation of patients suffering from CLP.[9]

It is concluded that in the case of the unilateral cleft, the infant should be seen on a weekly basis for continuous follow-up prior to surgery. The desirable achievement therapy is highly determined by supportive parents to accomplish all the sequence therapy. In all cases of clefts, the final assessment of clinical treatment is possible only after the patients have reached the adolescence.

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DOI: 10.46934/ijp.v4i2.213

Removable partial denture with telescopic overdenture

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ABSTRACT
Telescopic dentures have better retention and stability than conventional complete dentures. It improves masticatory efficiency, patient comfort, and reduces alveolar bone resorption. This article reports an overdenture telescopic denture as a treatment option in progressive bone loss, low stability and retention, loss of periodontal proprioception and low masticatory efficiency. A 35-years-old female came to RSGM Unhas, with complaints of difficulty chewing food due to the loss of several posterior teeth of the upper jaw and lower jaw. The patient felt pain when chewing due to cavities. The patient wanted to retain the remaining teeth and wanted minimal denture-covered mucosa. After considering all factors, a telescopic overdenture removable denture RA and RB was recommended. Intraoral examination dental caries 13,11,21,22,23,34,35,45; edentulous 12,14,16,24,25,37,36,44,46 anterior deep bite, normal occlusion. It was concluded that the evaluation of occlusion, aesthetics, phonetics and comfort showed that the patient was satisfied, could speak, chew well while using his denture.
Keywords: telescopic, overdenture, removable partial denture

INTRODUCTION,

Loss of permanent teeth in adult patients without replacement can result in impaired masticatory, esthetic and phonetic functions. In addition, there can be disturbances in the balance of the masticatory organs in the mouth, such as migration of neighbouring teeth, extrusion of antagonistic teeth, loss of contact, caries, gingival recession and periodontal pockets which cause more complex dental and oral health problems.[1]

Definitive overdentures have been used to rehabilitate partially and completely edentulous patient overdentures were defined as removable partial or complete dentures that cover and rest on one or more remaining natural teeth, roots, and or/ dental implants. Additionally, overdentures may be defined as dental prostheses that replace the lost or missing natural dentition and associated structures of the maxilla and/or mandible receiving partial support and stability from one or more modified natural teeth.[2]

Telescopic overdenture is a development of conventional overdenture, with more advantages than conventional overdenture. The concept of a telescopic crown comes from an optical microscope that works on the principle of movement between two parallel cylinders. Telescopic crown is a denture with a combination of tooth and mucosal support, is a removable prosthesis that is designed to fit the natural tooth and the surrounding soft tissue in order to replace the missing tooth.[3]

The telescopic crown prosthesis consists of a) coping primers or caps, made of precious or base metal, cemented onto the prepared tooth; b) secondary coping (alloy metal) which is inserted into the secondary crown, with the aim of retaining the tooth through a sliding friction mechanism that is tight on the tooth. This secondary coping has a facing surface which will be filled with acrylic resin, composite, or ceramic; c) the skeleton is made of base metal alloy embedded in acrylic resin to support acrylic teeth which will serve to replace the missing teeth.[3]

Prosthetic rehabilitation of a partially edentulous patient can be established by using a wide range of treatment options. Most preferred prosthetic approaches are conventional removable partial dentures (RPD), teeth or implant supported overdentures, fixed partial dentures, and implant supported fixed or partial dentures (ISFPD). Conventional removable dentures, supported by remaining teeth and alveolar tissues, have been widely used. However, the traditional retention systems such as metallic clasps, frequently used in these conventional removable dentures, impose lateral forces on remaining abutments, increase abrasive wear, and cause unaesthetic appearancecase.[4]

Rehabilitation therapy with these anchorage methods could increase retention and stability compared to conventional RPDs retained by clasps and have aesthetic advantages due to the absence of any visible metallic clasps. This procedure is a simple, economic and conservative solution, which retains the principles and advantages of classic overdentures[5]

CASE

A 35-year-old female patient referred to Department of Prosthodontics, Faculty of Dentistry, Hasanuddin University, for esthetic problem and chew-

DOI: 10.46934/ijp.v4i2.240

ing inability. After obtaining her medical, dental, and social histories, the patient was examined clinically and radiographically; shows that she had lost her many teeth in the upper jaw and the lower jaw due to periodontal diseases and caries. Intraoral examination shows edentulous 14,15,16,21,24, 26,34,36,37,46,47; anterior deep bite, normal occlusion (Fig.1).

MANAGEMENT

Anatomical impressions were taken on the first visit (Fig.2). Then, preliminary treatments were done before the prosthodontics treatment; scaling on all remaining teeth, full crown preparation for telescopic crown on teeth 13,22,35,44,45. Gingival retraction with thread and adrenaline, as well as printing of the working model with a perforated stock tray with PVS impression material (Fig.3). Making temporary crown with acrylic self-curing material and the laboratory process is carried out for the manufacture of double crowns.

After the primary coping framework was completed, a try-in was performed on teeth 13,22 and 35,44,45. Check the edge accuracy of the primary coping framework. The impression was made with PVS impression material along with the primary coping framework and sent back to the laboratory for the final process of making primary coping, secondary coping, and metal frame partial denture base (Fig.4), After primary coping, secondary coping and finished base, a trial pair of primary coping was performed on teeth 12,13 and 35, 44,45. The impression is made with PVS impression material along with the primary coping framework (Fig.5), and sent back to the laboratory for the final process of making primary coping, secondary coping, and removable partial overdenture metal frame base. At the next visit after primary coping, secondary coping and base of RPD finished metal frame, trial and error of primary coping was performed on the teeth (Fig.6,7). After all the crowns were delivered and cemented, the partial removable telescopic overdenture was inserted (Fig.8,9), checking for retention, stabilization, occlusion, esthetics and patient comfort in wearing dentures. If there is a traumatic occlusion, grinding is done on the traumatized area.

DISCUSSION

The treatment of this patient is telescopic partial removable overdenture on the upper and lower jaw. Overdenture is one of treatments for patients who have bad conditions of teeth-crowns but good conditions of periodontal tissue and teeth's root, which can support the denture.[4] Overdenture can improve support and denture stability, increase the supporting teeth's life expectancies, and inhibit resorption of the residual ridge.[6]

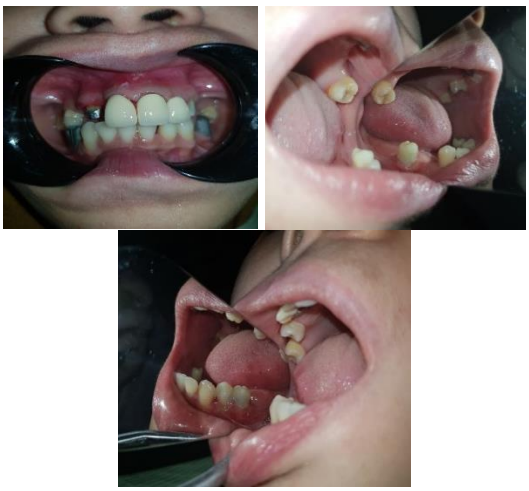

Figure 1 Intraoral condition left and right sides view

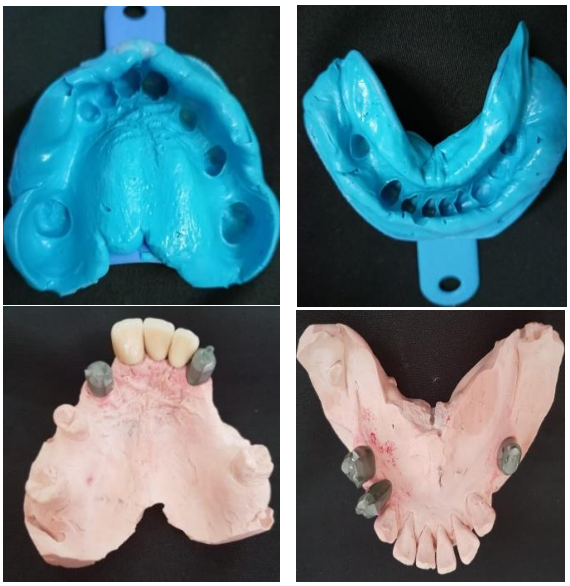

Figure 2 Anatomical impression using an irreversible hydrocolloid impression

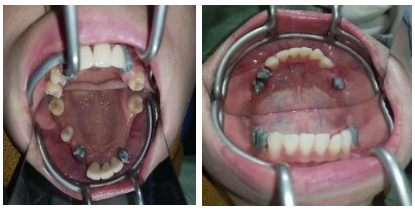

Figure 4 insertion trial of inner coping

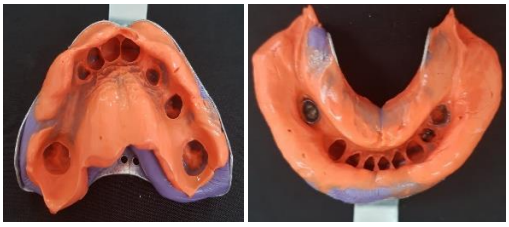

Figure 5 Pick up impressions

DOI: 10.46934/ijp.v4i2.240

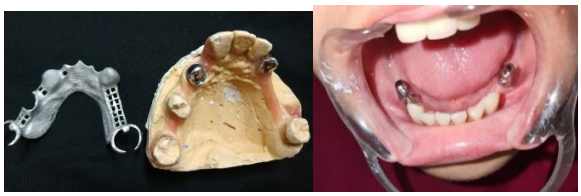

Figure 6 Primary coping and cementing primary coping

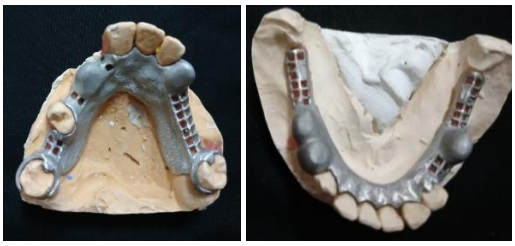

Figure 7 Metal frame design

Figure 8 The set-up of artificial teeth on metal frame

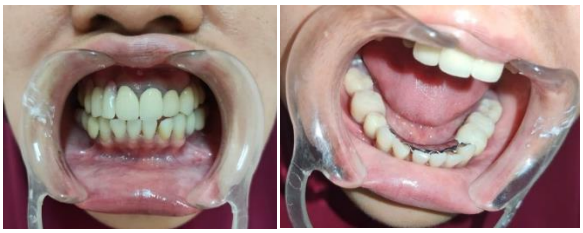

Figure 9 Telescopic RPD insertion

Some of the benefits of the telescopic overdentures include the prevention of bone loss, esthetic appeal, improved speech when compared with other types of dentures), proper jaw alignment, and improved chewing efficiency. Periodontitis oral disease that is dreaded that causes the gums to recede, loosening teeth, and eventually leading to loss of teeth.

The telescopic denture is best suited to restore new teeth for the periodontal patients. It consists of a double crown system knew as *the telescopic*, the procedure involves fitting the remaining natural teeth with inner metal crowns, followed by outer crowns as part of an overdenture that can be removed by the patient. The outer crown are modeled and cast together with the major connector in single-piece casting, so the partial denture structure in one piece.This technique ensures that bite stress is distributed evenly between each tooth, protecting the remaining teeth and the end result looks quite natural.[6]

Total or partial edentulism not only leads to patient's impairment of oral function but also influences facial appearance and psychological conditions.[4] Rehabilitation of an edentulous patient is a complex situation that several treatment options should be developed to solve this problem. While the conventional dentures like removable partial or complete dentures are the most preferred restoration options, they also have several limitations. In removable complete or partial dentures, retention and stability are the main factors to reach the success of the rehabilitation.[4]

A telescopic overdenture has advantages of good retentive and stabilizing, rigid splinting action, and better distribution of stresses.[4] In the current study, according to the periodontal condition, the distribution, and the number of remaining teeth, teeth supported overdenture would be the most appropriate treatment option for mandibular partial edentulism. The main advantage of the telescopic overdenture in the present case is providing balanced stress distribution between teeth and soft tissues. The telescopic retainers decrease the proportion of most traumatic lateral forces and transmit the occlusal forces in the direction of the long axis of the abutment teeth.[4] Furthermore, due to the well stress distribution and continued proprioceptive sensation, telescopic overdenture also prevents residual alveolar bone resorption. It is also more aesthetic and and hygienic then conventional removable partial dentures.

The advantages and disadvantages of a telescopic overdenture are that it provides a good path of insertion, is easy to perform routine oral hygiene, is rigid so that it helps splinting of mobile teeth, distribution of pressure on the abutment teeth, provides a suitable abutment for removable partial overdentures even when remaining teeth with periodontal abnormalities, insertion it is much easier for the patient, accommodate future changes in the treatment plan, and is psychologically tolerated by the patient. The disadvantages are increased cost, complex laboratory procedures, large number of tooth reductions required, large number of visits, difficulty in obtaining esthetics, reduced retention after repeated insertion/separation cycles, difficult adjustment of retention forces.[1]

It is concluded that tooth supported overdentures with telescopic crowns may be preferred in the rehabilitation of partial edentulous patients to the conventional removable dentures, because of their advantages such as better retention, stability, stable occlusion, and chewing function due to the conservation of proprioception feedback.

DOI: 10.46934/ijp.v4i2.240

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DOI: 10.46934/ijp.v4i2.240

Relationship between complete dentures and swallowing ability

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ABSTRACT
The aging process causes changes in the anatomical structures of the oral cavity and pharynx that are closely related to the ability to chew and swallow. The use of a complete denture may prevent this to happen, but a lower mastication pressure is visible in complete dentures compared to natural teeth. This may have an impact on swallowing ability. In general, a complete denture improves the swallowing process and prevents oral cavity and pharynx changes. Several factors, such as denture thickness, the interaction of oral musculatures with the denture, and occlusal contacts will affect the effectiveness of the swallowing process. A proper and stable denture will improve the pharyngeal movement involved in swallowing, thus avoiding airway obstructions. It is concluded that the use of a proper complete denture is important as all four phases of the normal swallowing process are affected by the denture. Untreated edentulous jaws may cause oropharyngeal expansion which increases the risk of food bolus penetration into the hypopharynx and ultimately delay the pharyngeal swallowing process.
Keywords: aging, complete dentures, rehabilitations, swallowing

INTRODUCTION

Aging is an unavoidable process that will be experienced by all the living things. This process is associated with progressive changes related to time and will affect the increased susceptibility to disease. In the mouth, the presence of hard tissue disease and periodontal disease usually leads to tooth loss, which if it doesn't replace by the use of dentures can generate impaired mastication, swallowing, and malnutrition.[1]

Complete denture (CD) is one of the restorations indicated for patients who have lost all their natural teeth. This denture can be removed and installed by the patient himself, the purpose of using these dentures is to restore the masticatory function that is disrupted due to tooth loss. In addition, CD plays an important role in swallowing function.[2] The swallowing process involves the anatomical structures of the oral cavity, lips, teeth, hard palate, soft palate, uvula, mandibular bone, tongue, the floor of the mouth, larynx, pharynx, and esophagus.[3]

The aging process causes a decreased swallowing function in the elderly, this can occur due to changes in the anatomy of the oral cavity and pharynx which is associated with mastication and swallowing. In the elderly, the wearing of CDs become commonplace. Because it plays an important role in maintaining swallowing function.[4] The maxillary CD which covers most of the palatal mucosa where the mechanoreceptors are distributed, can cause physiological and functional disturbances such as discomfort, gag reflex, and poor tongue adaptation.[5] In addition, the difference in chewing pressure produced by lower dentures compared to natural teeth can have an impact on the ability to swallow.[6]

A denture wearer in the elderly has a role in maintaining the anatomy of the oral cavity properly so that it can contribute to the process of transporting food boluses from the oral cavity during swallowing. This scoping review was made to describe the effect of CD wearing on swallowing processes with the aim of knowing the relationship between CD wearing on swallowing ability.

LITERATURE STUDIES

The writing of this literature is in the form of a scoping review that summarizes and shows the results of existing research on a part of a particular topic or field of science. The steps taken in the preparation of this scoping review are determining study questions, determining the appropriate type of research, conducting study selection, collecting data in a chart, compiling and making a summary of the study results report. This scoping review was written based on Arksey's staging framework and the Preferred Reporting Items for Systematic Review Extension for Scoping Review (PRISMA-ScR) guidelines.[7,8] The research question used in the literature is *Is there a relationship between the use of CD and the ability to swallow*?.

To identify questions and objectives in this scoping review, the PCC formula was used. P (population) in patients wearing complete dentures, C (concept) is the effect of wearing CD on the ability to swallow, and C (context) is the patient's swallowing ability when wearing CD and the patient's reported condition. This formula was used in this scoping review to see the relationship between the

DOI: 10.46934/ijp.v4i2.214

Table 1 Literature search keywords

PubMed	((((swallowing) OR (deglutition)) AND (((((removable denture) OR (denture)) OR (complete denture)) OR (removable prostheses)) OR (removeable prosthesis))) AND ((effect) OR (impact))) AND (dysphagia)"full text,2011-2021"
Ebsco	(((((removable denture) OR (denture)) OR (complete denture)) OR (removable prostheses)) OR (removeable prosthesis))) AND ((effect) OR (impact))) AND ((Swallwoing) OR (Deglutition)" *Full text,* 2011-2021
Scopus	"((removable denture) OR ((Prostheses) OR (Prosthesis))) AND ((Swallwoing) OR (Deglutition) AND ((Effect))" *Full text*

Table 2 Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Period	In the last 10 years period	Outside the last 10 years period.
Language	English	Other than English.
Subject	Patients wearing complete dentures	Other than complete dentures, not wearing dentures, implanted dentures and complete dentures with implant support
Concept	The effect or impact of wearing dentures on the swallowing process	Does not discuss swallowing, does not include the impact or effect of wearing dentures on swallowing
Context	Patient's condition or ability to swallow while wearing complete dentures and reported general health	Does not discuss the patient's condition and ability to swallow and the health of the reported patient
Design	Randomized clinical trial, Cohort	case reports, studies, and meta-analyses.
Type of Publication	Full text, free full text	Does not have full text

wearing of CD and the patient's swallowing condidition and ability.

The literature review in this scoping review will focus on the impact or effect of dentures on the swallowing process. Literature searches were performed on three electronic databases (Pubmed, Ebsco, Scopus). The keywords used to search the literature are "((Denture)) OR ((Prostheses) OR ((Prosthesis) AND ((Swallowing) OR ((Deglutition) AND ((Effect)))" as shown in table 1, published in English for the last ten years and has the full text. Identification of relevant literature requires the existence of eligibility criteria in the form of inclusion and exclusion criteria in table 2.

After the literature was searched according to the criteria in table 1, screening was carried out because there are some duplicated literatures. The screening is also done by reading abstracts in each journal to pay attention to the inclusion and exclusion criteria. Appropriate literature will be included in this scoping review. Information such as author's name, year of publication, study design, data collection method, number of subjects, age, and treatment outcomes from the literature used will be reported in tabular form.

From the search strategy carried out, it was found 58 articles using the keywords summarized in table 1. A total of 38 literatures were obtained from PubMed, 6 articles from Scopus, and 14 articles from Ebsco. After the duplication check, there were 10 duplicated articles, 1 textbook article, and 1 non-journal article. The existence of articles that are considered relevant to the topic of scoping review is selected based on the title and abstract. Elimination is carried out with predetermined criteria and then read again to produce 7 final articles that will be used in this scoping review. The article search flow is shown in Fig.1. The results of the article review are presented in tabular form.

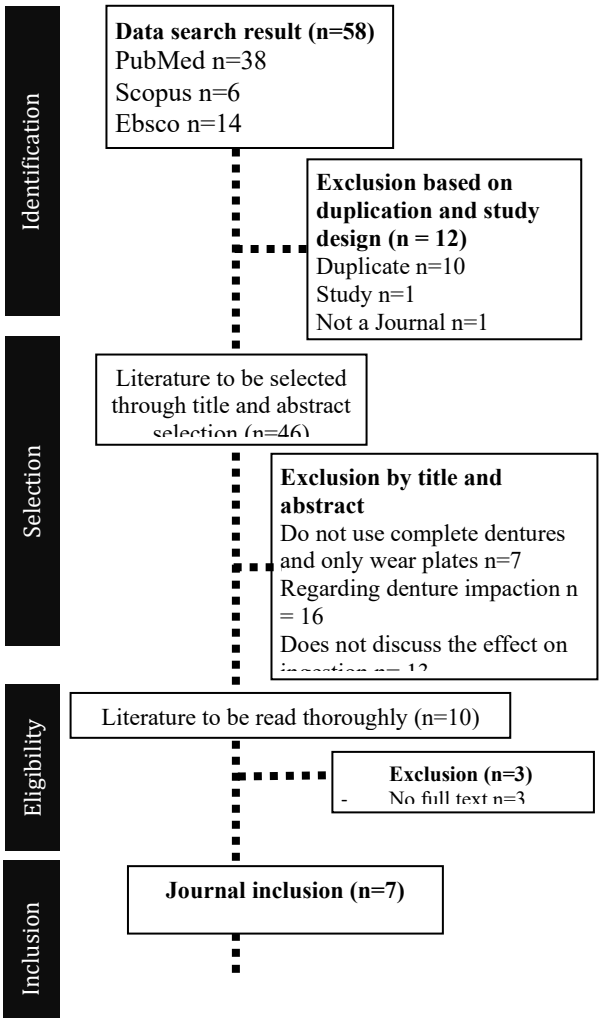

Figure 1 Diagram of the literature search and selection process based on PRISMA-ScR

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Scoping review

Table 3 The included studies and the effects of wearing dentures on swallowing

No	Author and year of publication	Research	Types of dentures	Number of subjects and mean age	Evaluation method	Effects of wearing dentures on swallowing
1	Onodera S, et.al (2016)	clinical experiment	complete denture	25 study participants aged 68 - 84 years	Observation of swallowing and eating, analysis of movement during eating and swallowing	The range of motion and duration of movement from the mandible can be shortened by wearing dentures, the elevation of the hyoid bone can be maintained by fixation of the mandibular bone by the occlusal contacts of the upper and lower dentures.
2	Gokce HS, et.al[5](2012)	clinical experiment	complete denture	23 study participants were edentulous with a mean age of >59 years and 23 participants were dentate with an average age of study participants >45 years	Observation of swallowing using MRI	The wear of dentures reduces the movement of the hyoid bone and larynx in edentulous subjects despite an increase in swallowing time in the oral phase with liquid boluses.
3	Yamamoto H, et.al[9] (2013)	clinical experiment	complete denture	15 study participants were edentulous and aged >72 years	Observation of feeding order with Videofluoroscopy	The wear of dentures helps maintain stability by normalizing oral function, then the bolus can be collected in the vallecular area controlled by the glossopharyngeal nerve so it will stimulates the receptive field enough to cause pharyngeal swallowing as soon as the bolus penetrates into the hypopharynx.
4	Kondoh J, et.al[4] (2015)	clinical experiment	complete denture	19 study participants aged 62 -90 years	Repetitive Saliva Swallowing Test, tongue pressure measurement	There is an increase in laryngeal movement from patients who wear complete dentures, the value of tongue motor skills is greater in patients who wear dentures compared to those without dentures.
5	Monaco A, et.al[10] (2011)	Clinical experiment	complete denture	20 study participants were edentulous and aged 54 – 70 years with 20 control group dentate and aged 51 – 69 years	Surface electromyography examination, computerized kinesio graphy examination of mandibular movement, recording of spontaneous swallowing of saliva	wearing of unstable dentures can prolong the duration of oropharyngeal swallowing, an increase in the duration of swallowing is also seen in new complete denture wearers compared to patients with complete natural teeth.
6	Furuya J, et.al[1] (2015)	Clinical experiment	complete denture	17 study participants were edentulous and aged 62 – 82 years	CBCT examination of the oral and pharyngeal mucosa, 3d measurements and pharyngeal description	wearing of dentures prevents changes in the shape of the oropharynx in an anteroposterior direction
7	Ibrahim AM[11] (2020)	Clinical experiment	complete denture	30 edentulous study participants aged 50 – 70 years	Evaluation of mastication duration, number of masticatory cycles, number of swallows, oropharyngeal residue by videofluroscopic	The wear of dentures prevents compression of the larynx and loss of occlusal support which can lead to decreased coordination of swallowing movements of the hyoid, larynx and tongue.

DOI: 10.46934/ijp.v4i2.214

DISCUSSION

The aging process will continue throughout life and occur naturally, this takes place gradually and is characterized by physiological and psychosocial changes. The changes in the body will affect the immune system, not to mention the oral cavity which as we grow old the immune system will graduate the oral cavity to become susceptible to diseases, such as inflammation, damage to the tooth structure, and tooth loss.

Tooth loss will affect the ability to masticate, swallow and speak. If not replaced, tooth loss can cause other health problems such as reduced food intake to malnutrition, or unhealthy food choices, which can lead to cardiovascular disease.[12] Tooth loss is thought to have a close relationship with swallowing disorders. Lim et al[13] stated that age, number of remaining teeth, and masticatory function have a relationship with each other and with symptoms of dysphagia or swallowing disorders.

To rehabilitate or prevent swallowing problems due to tooth loss, wearing CD is often chosen especially in geriatric patients.[1] The wear of dentures has a beneficial effect during the swallowing process because it can reduce the risk of laryngeal penetration, unstable swallowing movements, and stable palatal-tongue contact.[2]

Swallowing is a complex coordinated neuromuscular activity of structures in the oral cavity such as the pharynx, larynx, and esophagus that occurs rapidly. This process begins with a bolus of food that travels from the mouth to the stomach through the pharynx and esophagus, which is divided into 4 phases; they are the preparation-propulsive, oral, pharyngeal, and esophageal.[3]

In the preparation phase, the food bolus enters the mouth to be chewed and mashed. The process of mastication is a repetitive pattern, this process forms a lateral rotation of the muscles in the mandibular and labial regions. In this phase, the tongue moves the food over teeth and when the upper and lower teeth are in contact. The movement will destroy the bolus above it which is then returned again and helps the food bolus to mix with saliva. There is pressure on the buccal muscles, causing the food bolus to be stuck in the middle, so it can be continued to the next phase.

The oral phase begins when the food bolus starts moving posteriorly. The tongue will push the bolus posteriorly, which will trigger the next phase. In this phase, the cortex and brainstem will receive sensory information that comes from the stimulation of sensory receptors on the tongue and oropharynx, so that a swallowing reaction will occur which initiates the next phase.

In the pharyngeal phase, there is some activity of velum elevation, retraction, and complete closure of the velopharyngeal fortifications, preventing the food bolus from moving toward to the nose. The anterior movement and elevation of the larynx and hyoid, make the sphincter closes the larynx so that the food bolus does not enter the respiratory tract. The sphincter opens so the food bolus can go to the esophagus, then the base of the tongue tilts so the food bolus that goes to the pharynx will touch the anterior part of the posterior pharyngeal wall so the pharyngeal constrictor muscles will contract.

In the esophageal phase, the food bolus enters the esophagus and passes through the upper esophageal sphincter, then the food bolus enters the stomach through the lower esophageal sphincter. Peristalsis in the esophagus will push the food bolus to move toward the stomach.[14]

Based on the 7 articles obtained, the effect of wearing CDs on the swallowing process was discussed in all the literature used in this scoping review. In the study of Onodera et al[2] it was reported that when wearing CDs there was an adjustment in the movement of the hyoid bone, larynx, posterior pharyngeal wall, and upper esophageal sphincter. With the adjustment of these movements, wearing CD can help the swallowing function of the pharyngeal phase in edentulous patients when eating solid food in the perspective of spatial movement.

The range stability of motion was also reported in the study of Yamamoto et al.[9] In the denture absence, food boluses are retained in the hypopharynx because when swallowing the bolus, it cannot adequately stimulate the receptive fields in the valleculae and hypopharynx, and with increased hypopharyngeal transit time during swallowing without wearing dentures, the bolus will be fragmented in the pharynx and receptive pharyngeal mucosa is reduced when not wearing dentures.

Transit time on ingestion is another matter of concern. The study of Gokce et al[5] reported that in the oral phase, decreased swallowing time was found in subjects after wearing their dentures by swallowing 10 mL of water. This comes due to the sensation of the tongue and the palatal mucosal area being covered by the denture, so the thickness of the maxillary denture base is something that needs to be considered. The same thing was also reported by Monaco et al,[10] that the duration of swallowing was increased in subjects with occlusal contacts compared to subjects without occlusal contacts, apparently, the dentures were unstable,

DOI: 10.46934/ijp.v4i2.214

thus prolonging the swallowing time.

As reported by Jugo et al[4] and Abdalah[11] despite the shorter swallowing transit time, swallowing without wearing dentures can be dangerous in edentulous patients. The frequency of laryngeal penetration in subjects who did not wear dentures was higher than in subjects who wore dentures, this allows the entry of food into the respiratory tract becomes larger. The presence of occlusal contacts and intraoral deformities are thought to have an important role in this. The contours of the hard palate and maxillary teeth are coordinated with the movement of the tongue during bolus formation.[4] Anatomical changes in the oral cavity and pharynx also have a relationship with mastication and swallowing. Furuya et al[1] reported a significantly greater oropharyngeal volume in subjects who did not wear dentures than in subjects who wore dentures so if continued, the expanded oropharynx could worsen swallowing ability.

It is concluded that the changes in the structure of the oral cavity can affect its functions, the swallowing function is one of them. Impaired swallowing function due to tooth loss requires rehabilitation. Wearing CDs is expected to improve or rehabilitate swallowing function.

The presence of support in the occlusal contact and proper contact of the tongue with the palate will increase pharyngeal movement and prevent pharyngeal penetration. However, if there is a condition where all teeth are lost and they are not replaced with dentures, this can increase the penetration of the food bolus into the hypopharynx and delay the swallowing of the bolus in the pharynx during meals. Therefore, wearing CDs will avoid this and can maintain proper oral and pharyngeal anatomy and contribute to the transport of the bolus from the oral cavity through the pharynx for swallowing.

The quality of the CD needs to be considered. The thickness of the base plate in the palatal area affects the swallowing function. Impaired stability in CDs can prolong the duration of swallowing. The manufacturer of CDs must pay attention to the complex interactions between the muscle activity of the tongue, lips, and cheeks to avoid an imbalance of muscle strength exerted during swallowing. Unstable occlusal contacts can also affect the swallowing process because even though it is not visible, during the mastication process it they can affect the duration of the swallowing process.

It is suggested that wearing CDs has an effect on the swallowing process, it can prevent the decrease in swallowing ability due to tooth loss. Although the lack of research on CDs related to swallowing ability restricts this scoping review, further investigation is needed to provide a better understanding.

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DOI: 10.46934/ijp.v4i2.214

Implant-retained mucous supported overdentures

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ABSTRACT
The increase of life expectancy occurred along the demand of a denture that provides high masticatory efficiency to promotes high quality of life among the elders. Implant supported overdentures has been an attractive procedure because of its simplicity and minimal invasive, in which both the attachment part and mucous provide support, retention and stability. The purpose of this article is to show how to implement an implant and mucous supported overdenture with CBCT guidance to improve parallelized implant placement. A 55-years-old female came referred to Unpad Dental Hospital with complete loss of teeth. First phase of treatment was to make complete denture, following by duplicating the denture and used it as guidance in CBCT. Second phase was the implant stage which is two stage surgery. First stage surgery aimed to put two paralleled implant and followed by second stage surgery after three months. It is concluded that implant overdentures have many advantages to elder patient, which is less invasive, simple reconstruction, provides facial support, retention, stability and easily removed for hygiene.
Keywords: implant overdentures, overdentures, complete dentures

INTRODUCTION

Complete loss of teeth may present with lack of support therefore will affect retention and stabilization of the denture. This condition may reduce patient's comfort, less of mastication efficiency and have an impact to psychosocial.

There are two ways to use implant in complete denture, removable and fixed. Fixed implant supported denture cannot be removed by patient therefore more stable than the removable. This type is more complex in manufacturing process and inquire more implants so they are more expensive.[1,2] In the other side, removable implant supported overdenture (ISO) give a better outcome, easy cleaning hygiene, less expensive, and require less number of implant used rather than the fixed type. This type also restores better phonetic function and lost soft tissue due the support from the denture.[2]

The use of implants in complete edentulism improves outcome therefore the demand is increasing.[3] Based on support type, implant overdenture classified into two: a) implant-retained and mucous-supported overdenture, in which the denture is supported by soft tissue and retained by implant, also known as implant retained protheses (IRP), and b) implant retained and supported overdenture, in which the all the support and retention obtained from implant, so that it acts as fixed denture but can be removed for cleaning hygiene, commonly known as implant supported prostheses (ISP).[1]

Implant supported prostheses use more implant and rigidly attached to each other with bar, bar combination or other attachment. Since the support in implant-mucous overdenture (implant retained prostheses) obtained from implant and soft tissue, they use less number of implant. The denture is connected to the implant through a non-rigid attachment in the form of a bar, locator, magnet, or telescopic which will limit the movement of the denture during function and allow the mucosa to function as support.[2]

This case report presents the clinical steps of implant retained overdenture in lower jaw.

CASE

A 50-years-old female came referred by general dentist to Prosthodontic Department Unpad Dental Hospital with chief complaint to replace the complete loss of teeth. The patient never had dentures before and didn't have bad experience with extraction. Clinical examination shows complete loss of teeth with ridge resorption in lower jaw. Advantages dan disadvantages of different treatment option was discussed and patient was convinced for an implant and mucous supported overdentures.

The clinical steps were divided into two phase, first phase was to make the complete denture with sublingual impression and suction denture technique. Second phase was the surgery phase, which is 1) duplicate the denture as surgery template 2) CBCT were taken as imaging guide to place paralleled implants, 3) implant placement surgery, 4)

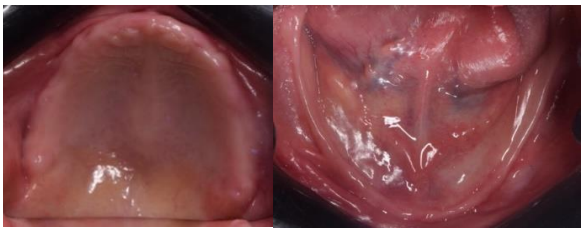

Figure 1 Intra oral view; **A** upper jaw, **B** lower jaw

DOI: 10.46934/ijp.v4i2.189

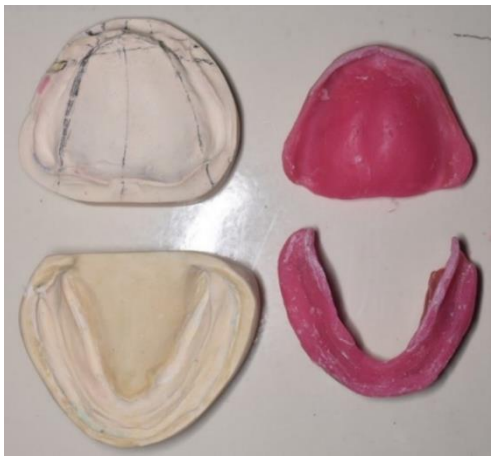

Figure 2 Working cast resulted from beading and boxing followed by bite rims

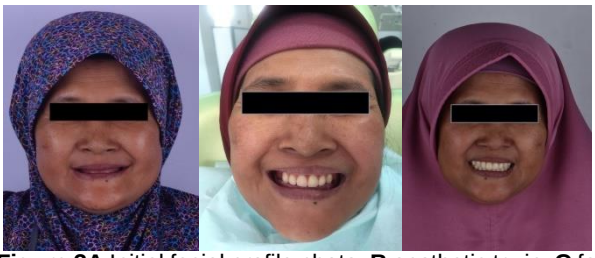

Figure 3A Initial facial profile photo, **B** aesthetic try in, **C** facial profile with final denture.

putting locator as retentive part.

Impression with irreversible hydrocolloid was made in the first appointment for diagnostic model. Private trays were made with light-cured acrylic for both jaw and muscle trimmed was done with green stick compound. Light-body polyvinyl siloxane was used for final impression. In the third appointment, vertical dimension (VD) and centric relation is established using bite rims that were fabricated on master casts. Color shade is taken and in the fourth appointment, aesthetic try-ins for anterior tooth is done (Fig.2,3).

Home care instruction was given in the fifth appointment as the denture placed and patient got recalled for one week. After one week patient show no difficulties to use her denture and was ready to the second phase.

Lower jaw denture was duplicated with the following steps: first, denture was pressed into a denture cup filled with heavy-body polyvinyl siloxane, and a thin layer of vaseline was placed on the surface following with final layer of heavy body PVS pressed and the denture cup was closed. After the impression was set, denture was removed, clear self-cure acrylic was mixed and poured into the mold.

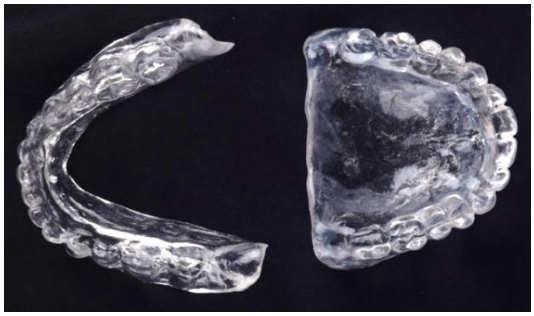

Figure 4 Surgical template made from clear acrylic. This template is made by duplicating denture.

The template denture was polished and holes were made on the incisal surface from teeth 33 to 43 teeth. With long needle bur the holes was drilled down parallel to the long axis of teeth and touched the base of acrylic. These holes were filled radiopaque gutta percha as guide in CBCT imaging. Patient used this denture while CBCT was taken.

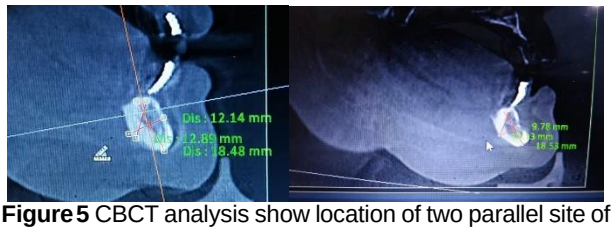

Figure 5 CBCT analysis show location of two parallel site of the mandible between both of mental foramen.

Two step surgery was taken and two implants (Osstem Implant 8 cm length, 3.8 cm diameter) were placed parallel to each other with denture template guide. One week later the suture was taken and the denture base around the implant site area were reduced. Patient was recalled after two months for second step surgery.

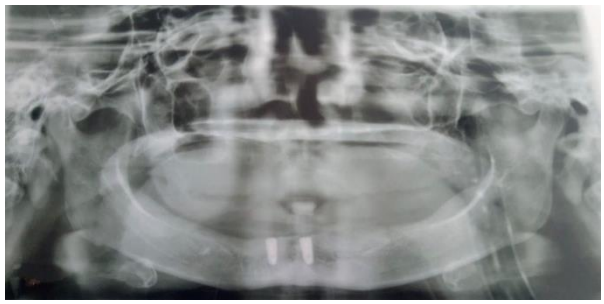

Figure 6 Panoramic radiograph showing implant parallelism.

Healing cap was placed in both implants to create soft tissue profile and after two weeks, the locator was placed. The anterior area of denture base was reduced, escaped holes were made in the lingual wall and with the locator was placed with self-cure acrylic. Home care instructions were discussed and patient recalled for two weeks. Patient showed satisfaction and better comfort in overdenture with implants.

DISCUSSION

Removable implant supported in complete denture (implant overdenture) is superior to conventional complete denture in terms of stability and re-

DOI: 10.46934/ijp.v4i2.189

tention and it improves the function, aesthetics, and phonetics of patients it also reduces the residual ridge resorption. This superiority was reflected in the McGill consensus and the York consensus which stated that the treatment of choice for an edentulous mandible should be a two-implant retained overdenture.[2]

Fixed rehabilitations for mandibular edentulous patients seem to be a well-accepted treatment from the patients' oral health perspective. However, mandibular overdentures are no less efficient than fixed prostheses in terms of clinical outcomes.[4]

Patients with limited hygiene maintenance ability are good candidate because of the abutments and increased access, the overdenture works well for patients with limited hygiene maintenance ability.[5]

Implant overdenture might be considered a better treatment option to fix in patients with excessive ridge resorption which has led to the loss of facial support of the lips and soft tissues of the face and has high aesthetic requirement; inadequate access/ability to maintain good oral hygiene around the implants/prosthesis; where the number, positioning or angulation of the implant fixtures are inadequate for a fixed reconstruction; when multiple surgical procedures such as bone grafting is contraindicated; and when the financial expense and time are restricted.[2]

Implant overdenture is indicated in patient who cannot tolerate the denture because of emotional reasons or because of gag reflex. Phonetic problems are caused by a difficult control of the saliva movements between the prosthesis and the maxillary gum.[5]

The IRP achieves support from both implants and tissue whereas the ISP achieves support only from implants. According to Misch, as ISP is stabilized on multiple bars between implants, the attachment clips located on each bar are frequently not parallel to one another or perpendicular to the posterior ridges. Therefore, the clips can bind in function, limiting prosthesis movement. This can produce a reduced range of motion between the prosthesis and bar attachment, increased prosthesis support from implant and increase applied torsional forces to the implants.[6]

In clinical situations involving poor posterior ridge form, reducing posterior support mucosal support in this manner may be advantageous as it prevents rotational movements of the prosthesis. Similar to a fixed prosthesis it creates a stable occlusal plain and prosthesis position reducing possible jaw resorption in posterior mandibular and anterior maxillary regions.[1]

The anterior posterior (AP) spread should also be contemplated during the planning stages. This is the distance measured from the most anterior implant in the arch to the most posterior implants. With regards to implant retained overdentures the AP spread has a bearing on the overall stability of the denture.[13] In general, the greater the AP spread of the implants the less AP movement that occurs with the prosthesis.

The implants act as a fulcrum with two potential level arms: 1) from the fulcrum to the posterior extension off the denture and 2) from the fulcrum anteriorly to the incisal edge. forces on either lever arm will produce rotation. However, the primary and secondary bearing areas of the overdenture will resist occlusal forces placed on the posterior lever arm, but forces on the anterior lever arm, such as incisive movements, may cause more noticeable rotation. By moving the implants from the canine to the lateral incisor position, the effective anterior lever arm is reduced, thus minimizing the tipping forces on the overdenture. [7]

It is generally accepted that in the mandible two inter-foraminal implants are the minimum number of implants required to provide a complete implant-retained overdenture. Unless the implants are very short (8 mm or less) or they are severely diverggent (more than 20°), they need not be splinted.[8]

Sadowsky[9] suggested multiple implants for mandibular overdenture when sensitive jaw anatomy, Increased occlusal forces, or high attention needs are present or when implant length <8 mm or implant width <3.5 mm are employed.

The final location of the implant in relation to the bone and the prosthetic teeth will help decide the type of attachment system used. This should be determined at the treatment planning phase before the placement of implants. Where a pre-existing satisfactory prosthesis is unavailable, fabrication of a conventional prosthesis with ideal tooth position we'll help determine appropriate implant position. In order for the individual attachment to provide adequate retention, all the implants need to be placed as parallel to each other as possible. [2]

The majority of complications and/or maintenance issues appeared to occur more frequently within the first year and one of the major factors relating to maintenance issues associated with the attachment system it's related to correct positioning of the implants,[10] and therefore implant positioning should be very carefully planned.

DOI: 10.46934/ijp.v4i2.189

The inter-implant distance also needs to be considered. Splinting of the implants with a bar shield not be carried out when the inter-implant distance is excessive, particularly as bars have been shown to transmit more forces to the implants.[11]

Implant length and inter implant distance in two-implant supported overdenture have no significant effect on marginal bone loss, but instead implant diameter found to be a critical factor.[12]

The selection of the attaching mechanism for an implant retained overdenture depend on implant number, implant position, inter-arch space, movement of the denture and stress distribution,[2] cost effectiveness, amount of retention needed, expected level of oral hygiene, amount of available bone, patient's social status, patient's expectation, maxilla mandibular relationship, inter implant distance, and status of the antagonist jaw.[11]

IRP with ball or bar and Clip attachment design allows a significant amount of rotation and vertical movement due to soft tissue resiliency and leads to residual ridge bone loss. Therefore, for the functional success of an IRP an optimal extension and fit of the denture is important. Rigid attachments have been shown to distribute increased forces to the implants in comparison to resilient attachment.[11]

Inadequate space for prosthetic components can result in an over-contoured prosthesis, excessive occlusal VD, fractured teeth adjacent to the attachment, attachments separating from the denture, fracture of the prosthesis and overall patient dissatisfaction.[1] A reported minimum space requirement in the vertical plane (interocclusal space) from the platform of the implant to the opposing of collusion for implant overdentures with locator attachments is 8.5 mm,[8] implant retained overdenture with a bar requires 13-14 mm and an implant-retained overdenture with other freestanding attachments Is 10-12 mm which can be assessed clinically.[14]

According to Martinez,[15] selecting an adequate retention system depend on a) It is a upper or lower jaw. In the mandible it will be easier to place parallel implants, thus, ball or locator attachments will be indicated; b) arch form: bar attachments will be indicated in wide arches. On the other hand, in narrow arches using bow or locator attachments would be indicated, c) bone resorption rates and implant length: If implant is at least 10 mm long, it can be used as unsplinted, but if it lasts than 10 mm long it will be indicated that the implants be splinted with more attachment; d) implant location: if implants are placed quite far from each other it will not be indicated to use bar attachment due to increase of bond stress.

Abutment parallelism is very critical for the solitary implants as abutment non parallelism leads to faster wear of the matrix. Therefore, with increase in number of implants splinting should be done as abutment parallelism becomes more difficult. In V-shape anterior mandibular ridge, if bar is placed at canine location, it encroaches on the tongue space and if placed anteriorly, length of the bar becomes inadequate. Therefore in such cases, ball attachments or 3-4 implants with a connecting bar supported overdenture is indicated.[7]

In edentulous mandible, implant retained overdentures provide excellent long-term success and survival, including patient satisfaction and improved oral functions. To further reduce the cost, a single midline implant overdenture can be a promising option.[16] Increase in number of implants did not significantly improve the patient satisfaction.[17]

Survival rate and the peri-implant tissue resppponse in a group of patients who received two unsplinted immediately loaded dental implants in the mandibular anterior to retain a complete overdendenture using locator attachments was studied by Al-Dharrab and found at 3 years, all implants had osseointegrated with a 100% survival rate.[18]

It is concluded that compared to conventional removable prosthesis, implant retained overdenture have improved retention and stability, and patient satisfaction levels are reported as high. Clinicians should discuss with the patient considering all the factors to achieve optimum results.

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DOI: 10.46934/ijp.v4i2.189

Presurgical nasoalveolar molding as an effective adjuvant therapy to aid rehabilitation cleft malformations in newborn

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ABSTRACT
Cleft lip and palate (CLP) is a congenital anomaly that commonly occurs in the mouth and maxilla. Cleft lip and/or cleft palate can alter a child's appearance, affect pronunciation, swallowing and chewing, and lead to varying degrees of psychological damage in growing children involving the upper lip, hard palate, soft palate and nose. The goal of primary closure of CLP is to ensure normal and symmetrical lips and nose. Presurgical nasoalveolar molding (PNAM) is a non-surgical method reshapes the lips, alveoli, cleft palate, and cleft nose to minimize the severity of cleft lip deformity prior to cleft palate and primary cleft palate surgery. This article is aimed to review management of CLP in newborn using PNAM. It is concluded that PNAM is an effective adjuvant therapy to reduce preoperative hard and soft tissue cleft malformations because helps improve nasal aesthetics, reduce cleft size, and correct the maxillary arch with reduction of alveolar size and cleft palate.
Keyword: cleft lip and palate presurgical nasoalveolar molding, nasoalveolar molding

INTRODUCTION

Cleft lip and palate (CLP) deformity is a congenital abnormality of the middle third of the face. The incidence ranges 1:500-1:2500 live births. The etiology depends on heredity and the environment.[1] The CLP can present with considerable variation in severity and shape. A wider cleft is associated with a significant nasolabial deformity.[2] Labiopalatoschisis or CLP, is a craniofacial congenital abnormality caused by abnormalities of facial development in the embryo. Teratogenic environmental factors and genetics play a role in the formation of labiopalatoschisis.[3,4] The CLP is a common birth defect. Both can affect several body systems and functions, including eating and drinking, facial development, teething, speech, and can have a social and psychological impact on children and parents[5] (Fig.1).[6]

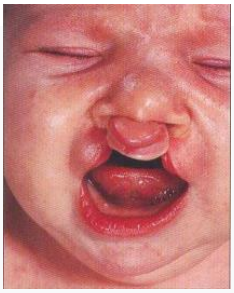

Figure 1 Extraoral profile of CLP patient (Source: Taylor TD. Clinical maxillofacial prosthetics. Chicago: Quentessence Publishing Co; 2000.p.70)

Veau's classified CLP as type I, vermilion defect or red part of the lips; type 2, cleft covering the vermilion and part of the lip muscles up to but not including the base of the nostril on the affected side; type 3, unilateral CLP involving the entire thickness of the lip usually with nasal deformity; type 4, bilateral cleft lip, either partial, complete, or in combination.[7]

In the early of 17th century, Hoffman was the first scholar to use headgear as an anchor to retract the protruding anterior jaw and to narrow the cleft. Mc Neil used a palatal resin plate to move the fractured alveolar bone to its normal position. Hotz et al used an elastic resin material to make the maxillary palatal plate, which is worn from birth. After cleft lip surgery, it continues to be used until cleft palate surgery and eruption of the first primary molars. This appliance uses the maxillary growth itself to align the alveolar bone segments. The Latham appliance can retract the anterior portion of the protrusion, moving the affected alveolar bone segment forward and expanding the posterior alveolar bone segment. These methods can only correct serious alveolar bone displacement, but not nasal deformities.[8]

Preoperative orthopedics has been used since 1950 as an adjunct procedure for the correction of premaxillary protrusions in the cleft. Presurgical nasoalveolar molding (PNAM) was developed by Barry Grayson, Orthodontist in 1993, it assists in the reduction of intraoral alveolar cleft size, active molding and positioning, performed on newborns and reduction of the surgical area and the resulting scar tissue.[9]

Grayson et al describes a new technique of presurgical impressions of the alveoli, lips and nose in infants born with CLP. It has been shown that correction of nasal cartilage deformity and nonsurgical elongation of columella deficiency can be achieved in combination with impression of the alveolar process with premaxillary retraction via PNAM. This

DOI: 10.46934/ijp.v4i2.241

is possible because cartilage has a high degree of plasticity in the neonate. The transient plasticity of cartilage is caused by high levels of hyaluronic acid, a component of the proteoglycan intercellular matrix found circulating in infants for several weeks after birth. Matsuo dkk., Matsuo and Hirose are people first to use this plasticity to remove nasal cartilage.[10,11]

The main goal of treatment in cleft lip patients is to restore normal anatomy and function. Reconstruction of symmetrical lips and a natural-looking nose is a difficult challenge in unilateral clefts.[10] Advances in reconstructive surgery have significantly improved the quality of repair for cleft lip, alveolus, and palate; surgery alone cannot correct all aspects of cleft defects.[12]

Nasal deformities improve over time if left untreated. Uncorrected nasal deformities also leave cleft stigmata until adolescence. Also secondary correction of the nasal deformity will lead to more surgical scarring and less than ideal results. So, any form of non-surgical treatment to reduce nasal deformities early in life is highly desirable.[13]

The PNAM overcomes various problems associated with traditional methods for treating unilateral CLP. This increases the asymmetry of the nose and less nasal tip.[14] It also forms the protruding premaxillary segment into a more normal alignment with the alveolar segment, improves the shape of the maxillary arch and also reduces the size of the cleft lip, palate and alveolus. This reduces the complexity of subsequent surgery and also provides a more aesthetic result.[15] The aim of this literature review is to learn more about the management of CLP in newborns using PNAM.

LITERATURE REVIEW

The PNAM is an effective method to enhance the maxillary growth and development of CLP patients. PNAM is a new technique that acts as a specialized form of tissue expansion while correcting nasal cartilage deformities without surgery and resolving columella length deficiency and alveolar segment malposition with minimal surgery. The result is an overall improvement in the aesthetics of the nasolabial complex while minimizing the extent of surgery and the number of surgical procedures, thereby providing a positive psychological impact for the parents. Therefore, this literature review aims to find out more about the management of CLP in newborns using PNAM.

The PNAM is a non-surgical method of reshaping the alveolus, lips and nostrils prior to primary surgery for CLP.[5] PNAM technique consists of an intraoral plate that supports an acrylic nasal stent, which is joined with lip-band adhesion, shaping the nose, lips, and alveolar segments before surgery. The PNAM therapy has been used successfully in patients with bilateral and unilateral cleft lip[9] (Fig.2).[6]

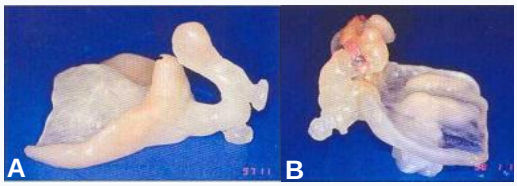

Figure 2 The PNAM prosthesis with nasal stent (lateral view); **A** unilateral NAM prostheses, **B** bilateral NAM prostheses (Source: Taylor TD. Clinical maxillofacial prosthetics. Chicago, Quentessence Publishing Co; 2000, p.70)

The NAM process in the global protocol for the management of CLP has been approved for several years. It begins in the early neonatal phase, and continues after labioalveolar plastic surgery, usually starting at 6 months after birth. This parallel orthopedic therapy with surgical therapy ensures restoration of the cartilage that forms the collapsed nasal wing, the columella often tilts to the split side and contributes to the restoration of the lip relationship, which facilitates the surgical procedure. PNAM targets not only the labionasal soft tissues, but also the bone supporting tissues. Terminologically, the term *molding* has been used to describe soft tissue procedures and orthopedic procedures on bone. Nevertheless, it cannot be denied that soft tissue imprinting is also an *indirect orthopedic* due to the changes in muscle and cartilage brought about by the influence of modeling the underlying supporting bone. Thus, by ensuring lip approximation, this affects the centripetal action of the two jaw fragments adjacent to the cleft.[16]

The use of PNAM improves nasal symmetry before surgery. It appears that this change is beneficial after lip repair, as postoperative follow-up studies in patients treated with PNAM reporting improved symmetry when compared to patients treated without PNAM also suggest that PNAM may be a cost-effective technique by reducing the number and improving outcomes of secondary rhinoplasty procedures in future. In addition, a preoperative *symmetrical* nasal cleft with a narrower alveolar cleft is likely to simplify primary lip-nose repair. This can reduce surgical time, thereby reducing costs.[9]

Indications for the use of PNAM, especially for patients with unilateral or bilateral third degree CLP with severe cleft lip and alveolar process and nasal asymmetry, and mild unilateral or bilateral CLP. If accompanied by obvious nasal asymmetry, nose shaping treatment should also be considered; 7-14 days after birth is the best time to start nasal alveolus formation treatment. Because the plasticity of

DOI: 10.46934/ijp.v4i2.241

soft tissue and facial cartilage is best within three months after birth, especially nasal cartilage within 6 weeks after birth.[8]

The procedure for making PNAM according to Taylor,[6] that is 1) as soon as possible after birth, the infant is evaluated by all members of the interdisciplinary CLP team. Cleft defects are examined for the presence of natal teeth, Simonart bands, unusual undercuts, or other tissue abnormalities. If there is a tooth near the gap, it is often extracted because its presence will make healing difficult during the surgical treatment phase; 2) after thorough evaluation and explanation of the procedure and treatment goals to the parents, an impression of the intraoral cleft defect was made using an elastomeric material in an acrylic impression tray. Selected impreesion materials with very high consistency (Fig.3A); 3) the impression is done with the baby fully awake and without any anesthesia. The baby is held face down to prevent possible aspiration of regurgitated stomach contents. One person holds the baby securely around the chest, supporting the head and neck, while the other gets the impression (Fig.B,C)[6]; 4) the impression of the nasal

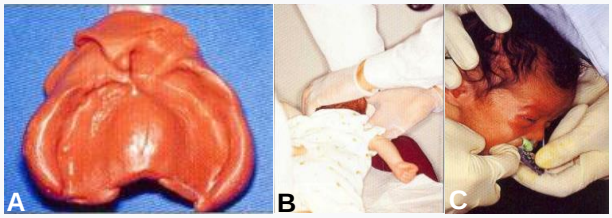

Figure 3A High-consistency elastomeric impression material on a special impression tray. Excess material on the back of the tray should be avoided; **B** techniques for obtaining intraoral impressions of cleft defects in newborns **C** the baby is carried on the stomach to prevent aspiration (Source:Taylor TD. Clinical Maxillofacial prosthetics. Chicago, Quentessence Publishing Co; 2000, p.71).

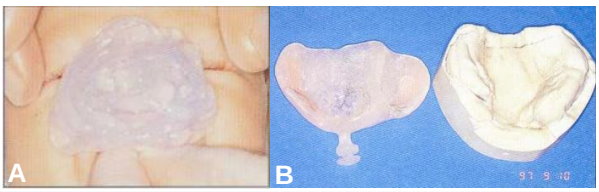

Figure 4A Clear PVS of nasal deformities can be obtained to study nose shape before and after imprinting. Nose molds are not used in the manufacture of nasal stents; **B** maxillary cast used to fabricate a unilateral intraoral impression of acrylic material (Source :Taylor TD. Clinical Maxillofacial prosthetics. Chicago, Quentessence Publishing Co; 2000, p.72)

area is not required but can be helpful in comparing the results of pre- and post-orthopedic impressions. Nasal impressions can be obtained using PVS which is expressed directly into the cleft nose from root to lip (Fig.4A).[6] Cotton plugs attached to dental floss are used to prevent material from entering deep into the nostrils. Nasal impressions are not used in the fabrication of the nasal stent portion of the nasoalveolar impression device; 5) when the material is fully set, about 2 minutes intraorally, the impression is removed and inspected to ensure all desired landmarks have been obtained; 6) the existing mold is then poured twice with gypsum impression material; one cast will be as a working model wherein an intraoral impression plate will be created while a second cast will be a record. The size of the defect at the alveolar level was measured on the cast impression and recorded. (Fig.4B)[6]; 7) the cleft palate and alveolus areas can be filled with wax to approximate the contour and topography of the intact arch prior to fabrication of the oral portion of the impression device. A small coating of petroleum jelly is then applied to lubricate the modified cast; 8) soft acrylic can be placed in the undercut area of the cast. The remainder of the plate molding was prepared from clear methyl methacrylate orthodontic resin using one of many acceptable techniques. Ideally, oral molding should be waxed from two layers of baseplate wax and then packaged and processed in the laboratory; 9) at the next visit, the molding device is carefully placed in the baby's mouth. Early attention was paid to device retention. A properly adjusted and properly constructed mold plate will usually hold up quite a bit on its own. After initially inserting the molding device, the infant should be observed for several minutes and the appliance stabilized on the roof of the mouth with the index finger by the doctor. Baby should be able to suckle easily without choking or struggling; 10) at this visit the tissue surface of the apparatus is also modified, through selective removal of acrylic from the desired movable area of the alveolar bone (Fig.5A).[6] Softliner is added to coat the appliance with a thickness of approximately 1-1.5 mm in areas where bone is desired to be reduced or removed (Fig.5B,C);[6]11) proper

Figure 5A Modifications were made to the internal surface of the molding tool with a bur along with the addition of hard acrylic and soft liner materials to direct the controlled movement of the alveolar segments to produce the desired arch shape and reduce the arch size of the alveolar cleft width; **B** internal surface of unilateral intraoral molding apparatus with acrylic retentive knob. Softliner material has been added; **C** diagram of weekly modifications to the internal surface of a unilateral mold tool to achieve a reduction in the gap width (Source: Taylor TD. Clinical maxillofacial prosthetics. Chicago, Quintessence Publishing Co; 2000, p.74)

DOI: 10.46934/ijp.v4i2.241

retentive adhesive between appointments is essential if the tool is to be maximally effective (Fig.6)[6]; 12) when the slit gap has been reduced to about 6 mm or less, a nasal stent can be added to the apparatus and the active nasal cartilage formation phase can be initiated. The nasal stent is an acrylic projection formed by the careful addition of a small amount of cold-cure acrylic resin until the stent is positioned within the nasal vault on the side of the nasal cleft (Fig.7);[6] 13) the nasal stent

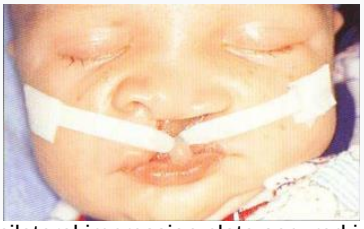

Figure 6 Unilateral impression plate secured in the infant's oral cavity with surgical and elastic bandages (Source: Taylor TD. Clinical maxillofacial prosthetics. Chicago: Quentessence Publishing Co; 2000, p.75)

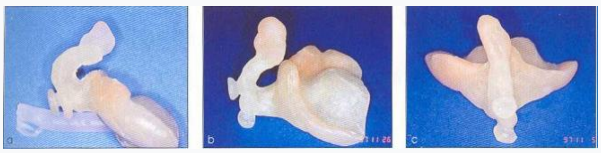

Figure 7A Initial nasal stent added in acrylic; **B** modified weekly to **C** final form (Source: Taylor TD. Clinical maxillofacial prosthetics. Chicago, Quentessence Publishing Co; 2000, p.76)

can also be made of 0.036 inch stainless steel wire attached to the labial flange of the tool (Fig.8A).[6] When the wire is used for the stent, the wire is carefully bent at the nose tip of the stent to project passively into the nostril; 14) the stent base ei-

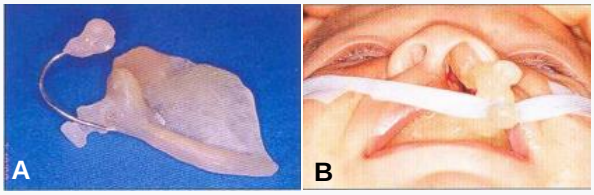

Figure 8A The nasal stent is made of 0.036 inch retentive wire, acrylic, and closed with a softliner; **B** nasal stent positioned in the nostril to support the dome and reposition the lower nasal cartilage at treatment week 13 (Source: Taylor TD. Clinical maxillofacial prosthetics. Chicago, Quentessence Publishing Co; 2000, p.77)

ther wire or acrylic, should be placed over the retaining button. The superior aspect of the acrylic nasal stent is covered with a thin layer of softliner material to ensure that positive elastic pressure is applied to the internal tissues of the nasal dome. The orientation of the nasal stent should be such that the tip of the nose and the dome on the cleft side protrude outward and toward the cleft side (Fig.8B)[6]; 15) the indentation is made with a wire, just below where the stent enters the nostril to make room for the edge of the nostril. The entire nasal extension of the stent wire is then covered with tough clear acrylic to provide shape and support to the tissue. Hard acrylic covered with softliner; 16) cleft nose deformity after nose shaping just before surgery. The alar base is now convex and the nasal tip cartilage has lifted. The lip segments are now closer to each other (Fig.9).[6]

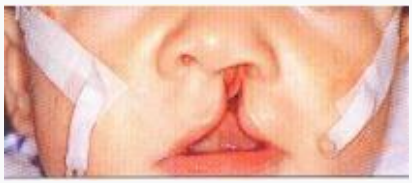

Figure 9 Cleft nose deformity after nose shaping just before surgery (Source :Taylor TD. Clinical Maxillofacial prosthetics. Chicago, Quentessence Publishing Co; 2000, p.77).

Complications of using PNAM are: facial skin rash, which is reversible without tools and a very low incidence of mouth and nose ulcers. The preventive measure for facial skin rashes is the use of an anti-allergic baby breathable tape, a tape width of about 5 mm. After soaking in warm water, remove the tape and adjust the position of the tape. Meanwhile, preventive measures for mouth and nose ulcers are to ask parents to clean their child's mouth and utensils every day, and stop using the appliance after finding redness and swelling of the nasal cavity or oral mucosa and ulcers. The nose ball's surface is smooth. Before use, apply vaseline or baby oil on the surface to lubricate it. The volume of the nasal ball increases gradually without using too much force.[8]

DISCUSSION

The PNAM therapy significantly reduced the alveolar and palatal clefts, and columella deviation. In combination, it helps align the maxillary arch. The symmetry of the nose is significantly improved. The columellar length is significantly increased, thereby improving the aesthetics of the nose. Nostril height significantly increased as nostril width decreased. All in combination increase the projection of the tip of the nose[6] (Fig.10).[17]

Nasal alveolar contouring therapy can narrow the alveolar gap because 1) the prone position is used to change the shape of the dental arch; 2) the medial surface of the palatal plate is adjusted to guide the growth of the bone segment; 3) strength provided by lip adhesive tape.[8]

The research conducted by Bajaj et al was in 2011, with modifications from Grayson in the treat-treatment and tools. The PNAM from the Grayson

DOI: 10.46934/ijp.v4i2.241

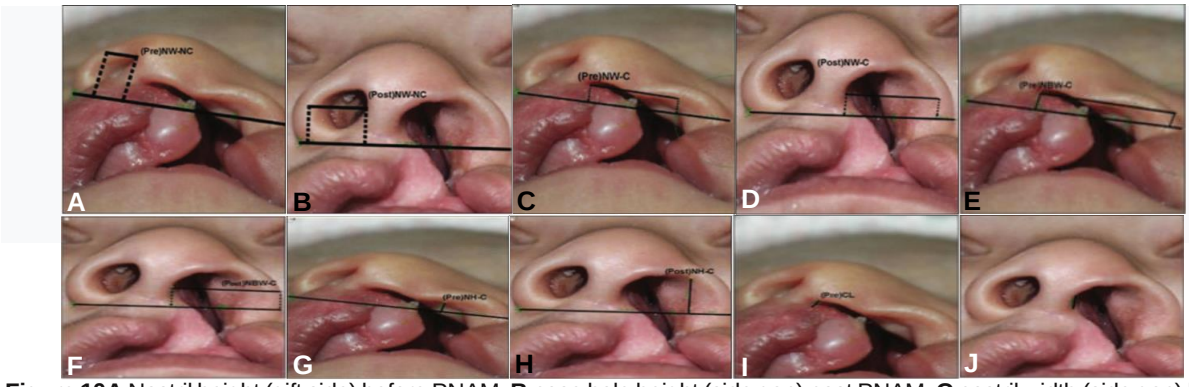

Figure 10A Nostril height (gift side) before PNAM, **B** nose hole height (side gap) post PNAM, **C** nostril width (side gap) before PNAM, **D** nostril width (side gap) post PNAM, **E** nostril basal width (side gap) before PNAM, **F** nostril basal width (side gap) post PNAM, **G** nose dome height (cleft side) before PNAM, **H** nose dome height (cleft side) post PNAM, **I** columella length (gift side) before PNAM, **J** columella length (gift side) post PNAM (Sumber: Zuhaib M, Bonathaya K. Parmar R. Presurgical nasoalveolar molding in unilateral cleft lip and palate. Indian J plastic Surg 2009;8(13):44-8)[17]

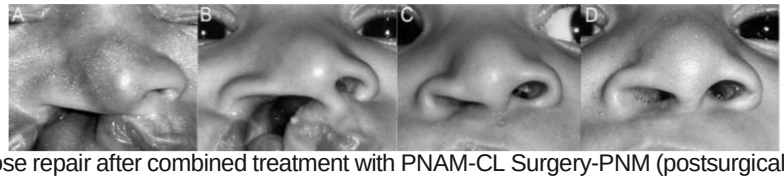

Figure 11 Cleft lip nose repair after combined treatment with PNAM-CL Surgery-PNM (postsurgical nasal molding). **A** before PNAM, **B** after PNAM, **C** after primary lip and nose repair. It seems that additional prints would be useful in this case, **D** after PNM, better nose contour was achieved after 1 month of treatment using a custom made acrylic nose conformer (Source: Gomez DF, Donohue ST, Figueroa AA. Nasal changes after PNAM in the unilateral cleft lip nose. Cleft Palate Craniofac J 2012; 11:699).

Technique requires weekly visits for 3-5 months, but in this study weekly visits were made up to 2-3 weeks. The molding plate, made of clear hard acrylic, is made on a dental stone model. The plate must be 2-3 mm thick for structural integrity. This mold plate is different from the conventional orthopedic plate as described by Hotz. The impression plate is made so that there is no extension of the plate into the alveolar or palatal cleft space. All undercuts and fissures are covered with wax so that the cast appears to have intact alveoli. At the same time two to three layers of wax are also added as spacers in the area of the main segment should move on the palatal side during treatment. The key to the modification is the removal of gaps and the addition of wax spacers. This modification prevents the need for weekly trimming of the occlusal apparatus as described by Grayson. This treatment is performed to smooth the plate boundaries and remove the attachment of the labial frenum sufficiently. Then the mold plate impression was adjusted to gradually approach the alveolar cleft segment, with the addition of an acrylic soft liner on the labial side of the main segment. The addition is made only medial to the attachment of the labial frenum. Alveolar impression and approximation were achieved only through the addition of soft acrylic at each follow-up visit. The thickness of the added soft acrylic was 1 mm or less per visit. The amount of soft acrylic added may vary depending on the clinical objective and the tolerance of the mucosa to ulceration. Selective removal of acrylic is usually not required from the palatal side. Also the adjustment period can be increased to 2-3 weeks as there is no interference with the movement of the larger segments due to the space provided by the addition of wax spacers during tool making. This increased follow-up visit interval reduced the burden equally on the cleft lip team and parents. Procedure is more time efficient and less tedious. This helps increase parental compliance. Parental motivation and teaching are critical to the overall success of treatment. Parental obedience makes an important contribution to achieving good results.[13]

A study was also conducted by Zuhaib et al in 2016 using the Liou technique, a modification of Grayson, involving 20 CLP patients. Through biweekly modification of the nasal bulb of the nasal mold and adjustment of the wire, the alar cartilage was carefully shaped to resemble its normal shape. The strength of the adhesive tape and the counterforce of the molded nasal bulb provide the necessary strength to bring the alveolus to its proper position. Furthermore, with regular selective lifting and the addition of a soft liner, the alveolus is molded. Significantly the results of these studies on evaluation, quantitatively demonstrated that PNAM therapy significantly reduced alveolar and palatal

DOI: 10.46934/ijp.v4i2.241

clefts, and columella deviation. In combination, it helps align the maxillary arch. The symmetry of the nose is significantly improved. The length of columellar is significantly increased, thereby improving the aesthetics of the nose. Nostril height significantly increased as nostril width decreased. They increase the projection of the nose tip.[17]

The research conducted by Alamsyah et al in 2022, by combining the Hotz plate design with the Kogo plate. The Hotz plate design is a passive type orthopedic plate that aligns the gap segment with the help of strapping using tape slowly. This tool is made with a combination of hard and soft acrylic. It covers the alveolar segment passively and extends posteriorly to the tip of the cleft in the uvula. Kogo plate design, 2 mm acrylic elevation is made on the posterior part of the plate. The modification of the Hotz-Kogo design is a combination of elevation of the posterior palatal mechanical surface and elongation to the cleft of the uvula, a nasal stent is placed to form the nasal cartilage. For unilateral CBL patients, the PNAM design used a single nasal stent, while for bilateral patients, a double nasal stent or prolabium box was used. This design is a combination of the Hotz plate that covers the alveoveolar segment and then extends posteriorly to the uvula will provide a good adaptation in creating a normal swallowing pattern, the addition of the Kogo plate design with a 2 mm elevation on the posterior plate which acts as a close box will increase retention on the plate, especially in infants with active soft palate movements and a high gag reflex. After observing and examining the patient, the reten-tion produced by the design proved to be good from the results of the device retention test with a light withdrawal method using a probe at one point in the anterior and two points at the posterior. The posterior close box also played a role in creating a normal swallowing pattern in this patient, characterized by good suction power, which was checked at each visit. The combination of the Hotz-Kogo modified PNAM design is seen in this case, the baby's sucking reflex is greater than the use of the Hotz plate. [18]

Pre-surgical nasoalveolar protocols and post-surgical nasal prints, should be used to improve the long-term outcome of this treatment approach taking into account 1) PNAM should endeavor to reduce and not increase the width of the alar base prior to surgery to facilitate future operations that shows *tapping* may be necessary to counter possible stretching of the tissue and/or changes in normal width growth; 2) PNAM treatment should be started as early as possible. This helps maintain the symmetry achieved. Neonatal hyaluronic acid, increased with a transient increase in estrogen levels, acts as a temporary barrier between intercellular material, giving cartilage a temporary lack of elasticity. If started later, the results will be less than satisfactory due to a decrease in the amount of estrogen and hyaluronic acid in the cartilage of the neonate. Consequently, the PNAM treatment in patients under 1 month of age is desirable and has led to higher subjective satisfaction than patients treated later; 3) PNAM treatment was extended as much as possible because longer treatment resulted in better nasal symmetry; 4) overtreatment of the patient to compensate for relapse and possible differential growth is a controversial aspect of the PNAM treatment. Caution should be exercised during PNAM not to increase the nostril circumference, *mega nostril*, and not excessively thin the nasal cartilage as a result of pressure. PNAM can cause an unstable nose; 5) the use of postoperative retention stents is highly recommended to improve the stability and shape of the nostrils. Postoperative use of acrylic or silicone stents has been recommended to maintain the surgical outcome achieved because recurrence is still a concern. In addition to commercially available stents, use an adjustable external nasal retainer to assist in the maintenance and enhancement of the postoperative nasal shape (Fig.11).[9]

It is concluded that PNAM has been shown to be an effective adjunct therapy for reducing hard and soft tissue cleft deformities before surgery. It is important that the parent or caregiver be an active member of the treatment plan. Studies show that PNAM therapy improves nasal esthetics, reduces cleft size and aligns the maxillary arch with a reduction in the size of the alveolar cleft and palate in patients. Therefore, PNAM therapy should be recommended in all patients with CLP as a routine procedure in treatment protocols, to improve surgical outcomes and improve aesthetics and function with minimal costs and operations.

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DOI: 10.46934/ijp.v4i2.241

Application of UV-resin in the fabrication of iris button to improve ocular prosthetic aesthetic

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ABSTRACT
Several methods for creating artificial iris are the use of iris from stock eyes, photo paper printing, painting with oil paints, and by implanting electronic components (dynamic iris). The oil painting method can produce an aesthetic 3D iris. However, when utilizing heat-cured acrylic resin to integrate the iris into the sclera, the use of a pressing machine when packing can distort the oil paint. This article is aimed to discuss the use of UV-resin material for iris fabrication can reduce the risk of distortion, reduce laboratory procedures, and produce an aesthetic iris. A 28-years-old male came to Universitas Sumatera Utara dental hospital with complaint of the previous ocular prosthesis felt loose and unaesthetic. Patient has been wearing the prosthesis for ±10 years and wants a new ocular prosthesis to replace the old prosthesis. Iris coloring is done with painting paper and oil paint, iris button is made with UV-resin using a pre-fabricated mold, then the iris is implanted into the sclera. The use of UV-resin for creating an iris requires only a few basic equipment and materials, has a quick-curing period, and facilitates iris position determination. It is concluded that fabricating ocular prosthetic with iris buttons made from UV-resin reduces the risk of laboratory failure and produces better esthetics.
Keywords: ocular prosthesis, iris fabrication, UV-resin

INTRODUCTION

The loss of an eye can cause functional and aesthetic impairment, followed by significant physical and emotional problems. The eye defects can be caused by congenital defects, trauma, or tumors.[1] Common surgical procedures of the eyes are evisceration, which removes the contents of the eyeball, leaving the sclera and cornea, and enucleation, where the entire eyeball is removed.[2] The presence of facial defects can cause significant stress to the patient. Therefore, rehabilitation of the eye defect with an ocular prosthetic should be started as soon as the healing is complete.[1] The resemblance between the ocular prosthetic and the original eye will increase patient satisfaction and help reduce impact on the patient's mental health after undergoing an enucleation or evisceration procedure. To achieve imperceptibility, when manufacturing the ocular prosthetic, the color of the iris and scleral vasculature must match the patient's original eye.[3]

Iris buttons can be obtained using several methods: using iris from stock eyes; using photo paper printing; hand painting with oil paints; and by using electronic components (dynamic iris).[1–7] The most popular and frequently used method in the manufacturing of iris is hand painting with oil paint. This technique is performed at the National Artificial Eye Service (NAES) and maxillofacial prosthetic centers by skilled ophthalmologists. The method of coloring by hand painting is still used because of its ease of adaptation and the ability to control color through color mixing when painting, but the result and quality depend on the skill of the ocularist.[3] Hand painting using oil paints can produce more aesthetic 3D irises compared to the stock eye methods, photo paper printing methods, and dynamic irises. However, the process of incorporating the hand-painted iris into the sclera using heat-cured acrylic resin (HCAR) requires the use of a pressing machine in the packing procedure, which can cause distortion to the oil paint on the iris. Therefore, UV-resin is used in the fabrication of the iris button to prevent distortion of the iris color.

CASE

A 29-year-old male comes to Universitas Sumatera Utara dental hospital with complaints that the old ocular prosthetic he is using feels loose and is not aesthetically pleasing because the ocular prosthetic looks inward, hence he wanted to make a new ocular prosthesis to replace the old prosthesis (Fig.1A). At the age of 3 years old, the patient's right eye was stabbed with a knife due to an accident, and has only been patched up without any surgical treatment. The surgical treatment, evisceration, was carried out when the patient was 19 years old (in 2021) due to the large protrusion in the patient's eye. Evisceration treatment was carried out at Adam Malik Hospital, then followed by the use of a conformer for 1 week before being referred to an ophthalmologist. The ocular prosthetic is done in one or two visits using stock eyes. The patient had used the prosthetic from 2011–2021 (10 years). From clinical examination, it was seen that the orbital socket mucosa was in good health.

DOI: 10.46934/ijp.v4i2.196

There was a deepening of the superior sulcus accompanied by ptosis, enophthalmos, and lower lid laxity. The patient's diagnosis was post-evisceration socket syndrome.

Figure 1 Patient profile; **B** primary impression

MANAGEMENT

Primary impression is taken by using a pre-fabricated-tray, made from self-cured acrylic and light-body polyvinyl siloxane material. Before the impression is made, the tray is inserted into the ocular socket to ensure the fit of the tray. Then, the patient is instructed to sit in an upright position with the head supported by the headrest. Petroleum jelly is applied to the patient's eyelashes to assist the separation from the impression material when set. The tray is then inserted into the eye socket and the PVS impression material is then injected in a slow manner. The patient is instructed to make ocular movements to capture the functional movement (Fig.1B).[8,9]

The impression is filled using the two-pour technique using a type IV dental stone. The first filling is done at the bottom of the mold, to the outermost point. After the bottom mold hardens, apply petroleum jelly on the surface of the dental stone and make orientation grooves, then proceed with the upper mold using type IV dental stone (Fig.2A). The wax pattern is obtained by pouring liquid wax into the mold. The wax pattern will then be sculpted according to the patient's original eye until a wax pattern that resembles the original eye shape and contour is obtained (Fig.2B).[8]

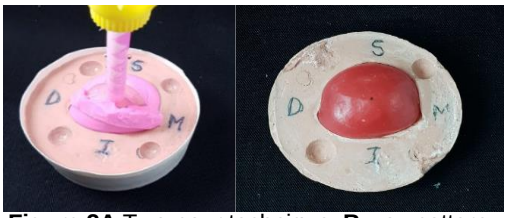

Figure 2A Two-pour technique, **B** wax pattern

After obtaining a wax pattern with the shape and contour that matches the patient's original eye, a duplicate of the wax/sclera from self-cured acrylic material is made and vacuumed in order to obtain a custom ocular tray that has the size and convexity that matches the patient's original eye (Fig.3).[8]

Final impression is made using the custom ocular conformer fabricated from the vacuum former

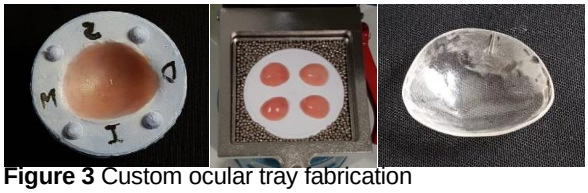

Figure 3 Custom ocular tray fabrication

Figure 4 Final impression procedure

Figure 5 Final impression mold

and light body PVS impression material. After insertion of the custom tray into the eye socket, the impression material is then slowly injected and the patient is instructed to perform functional eye movements, the acquired impression will be the final sclera shape (Fig.4). The impression is filled using the two-pour technique, using dental stone type IV. The mold is then filled with liquid wax to get the wax pattern (Fig.5).

The color of the iris and sclera is determined by using references from the original eye. The iris button is then made according to the color that has been determined, using painting paper and oil paint, and the iris button will then be made using UV-resin material using a pre-fabricated mold made using a vacuum former. The UV-resin is then cured using a UV lamp (Fig.6).

The wax pattern is then tried in the patient's eye socket to evaluate size, superior and inferior lid support, eye movement, and eyelid closure. Iris position was evaluated using the inter-pupillary distance ruler. For marking the position of the iris, the patient is instructed to look straight forward. The iris button is then embedded into the wax pattern and reinserted into the eye socket to confirm the iris position (Fig.7).[8,9]

The HCAR with a shade color that matched the patient's natural sclera was used to cast the wax pattern along with the iris button. After completion, the sclera and iris button are then reduced by approximately 2 mm in convexity. Sclera characterization was carried out by using red dacron fibers to simulate blood vessels to resemble the original eye.[9,10] A second casting was carried out to restore the convexity of the sclera using clear HCAR. The resulting ocular prosthetic is then polished, disin-

DOI: 10.46934/ijp.v4i2.196

Figure 6 Iris button fabrication using UV-resin

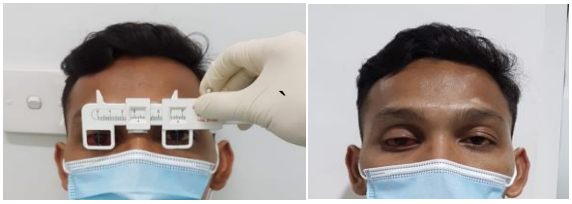

Figure 7 Iris positioning procedure

fected, and inserted into the patient's eye socket (Fig.10). The prostheses were evaluated in terms of esthetics, functionality, and comfort. Instructions were given for the maintenance and methods for insertion and removal of the ocular prosthetic.

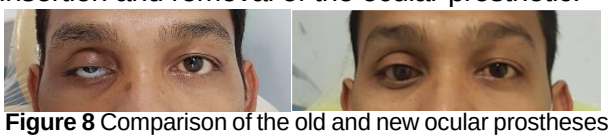

Figure 8 Comparison of the old and new ocular prostheses

DISCUSSION

In fabricating iris button, the stock eyes method, photo paper printing method, and electronic components (dynamic iris) methods will produce an iris without texture, making it less natural. In terms of function, the dynamic iris method is superior because the iris can dilate and constrict according to the ambient light. However, this electronic compoponent is still in the development stage.[4] The use of UV-resin in the fabrication of iris buttons in conjunction with the hand painting method can produce an aesthetic 3D iris button with a short curing time so a more natural and textured iris button.

Due to the UV lamp curing process and the absence of a press machine, which is often required when creating iris buttons from HCAR, UV-resin can be used to minimize the risk of distortion of the oil-painted iris. An additional advantage of using UV-resin is that it can simplify and reduce the laboratory processes required to fabricate an ocular prosthesis.

Due to its advantages, such as fast curing time, solvent-free formula, and low energy consumption, UV-resin base material has been widely used in various industrial fields such as coatings, printing inks, adhesives, dental composites, and photoresist. In this case report, the basic component in the UV-resin used is polyurethane acrylate (PUA) prepolymer. The PUA is one of the most widely used acrylic resins in the UV curing method due to its good abrasion resistance, flexibility, and hardness, as well as its solvent resistance.[11] The method for using UV-resin in the fabrication of an ocular prosthetic is safe to use because the iris button is sealed within the clear HCAR, and does not come into contact with the eye socket.

It is concluded that fabricating ocular prosthetic with iris buttons made from UV-resin will produce a more natural and textured iris button, reducing the risk of laboratory failure, simplified the laboratory process, and produces better esthetics.

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DOI: 10.46934/ijp.v4i2.196

Narrow-diameter implant in prosthodontics treatment

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ABSTRACT
Insufficient bone volume and narrow mesiodistal space often compromise Standard Diameter Implant (SDI) treatment planning. In order to achieve successful results, these compromises may incorporate prior treatment such as *guided bone regeneration* (GBR), block bone grafting, or distraction osteogenesis that requires extra time and cost and could result in unpredictable complications. A *narrow diameter implant* (NDI) is smaller than a standard diameter implant with a diameter less than 3.5 mm. This scoping review was performed to assess the use of NDI in prosthodontic care. It is concluded that NDI reasonably resembles SDI clinical success rate in terms of periodontal health, marginal bone remodeling, restoration, and patient satisfaction. The NDI offers similar survival rate to SDI, with promising long-term esthetic outcomes and can be used as the primary treatment alternative in restoring single tooth or splinted crowns in the anterior and posterior region, especially with narrow mesiodistal space.
Keywords: narrow diameter implant, small diameter, implant, treatment

INTRODUCTION

Missing teeth is a very common occurrence in dentistry. Nowadays patients' expectations are already shifted and see tooth loss as a very negative effect that can affect their daily life.[1] Patient consciously seeks treatment when experiencing tooth loss in the anterior region because it's affected their aesthetics, but when it happens in the posterior region, the patient tends to delay the treatment however patient should be educated more about the need for tooth replacement.[2] Clinically, the missing tooth that is not replaced can lead to extrusion of the antagonist teeth which will interfere with occlusion and complicate further rehabilitation. The tilting of the adjacent teeth is also one of the consequences of not replacing missing teeth and can increase periodontal abnormalities and caries development.[3] Thus, rehabilitation treatment for missing teeth should be able to restore masticatory function, speech, comfort, and aesthetics.[2-4] Several treatment options to replace lost teeth include removable dentures, fixed dentures, and also implant-supported dentures.[2]

Modern dentistry has developed towards restoring the patient's teeth to their original condition in contour, function, comfort, esthetics, speech, and restoring to a healthy condition by removing disease from the tooth or replacing it with a prosthesis. The trend of using implant-supported dentures compared to conventional removable dentures is also increasing in various countries such as South Korea, countries in Europe, and America. Therefore, implants in the field of dentistry continue to be developed with research, diagnostic tools, treatment plans, designs, cutting-edge materials, placement techniques, and predictions of success in various clinical situations.[4]

Implant restorations are reported to have had a high success rate, both in partial and total tooth loss.[5] By 2020, 90% of prosthodontists were routinely working on implant-supported restorations for both fixed and removable restorations. Implants are chosen by prosthodontists because they have several advantages over fixed or removable dentures, including maintaining bone, increasing occlusion stability and increasing chewing power, improving phonetics and restoring oral function, reducing the size of the denture (does not require a palatal base and does not require additional retention of the buccal and labial flange), improves the stability and retention of removable dentures, and can support both fixed and removable restorations, resulting in a more permanent denture. Although it is widely known, the development of implant restoration is still going to grow.[4] The requirements for implant placement require adequate bone volume and adequate mesiodistal edentulous space so that the implant can be placed properly. If there is a lack of bone volume, it can require a guided bone regeneration.[5]

Implants are well known for their qualified nature to be the most ideal treatment of choice for missing tooth cases. Some of the implant properties are designed to optimize implant placement, can produce primary stability, and must be able to distribute stress on the bone, and the structure on the implant surface must be able to provide cell adhesion and differentiation during the bone remodeling process.[4] For implants with a standard diameter or called *standard-diameter implant* (SDI) the average implant width is 3.75-4.1 mm and the required installation distance between implants or with neighboring teeth is 1.5-2 mm so that a total distance is

DOI: 10.46934/ijp.v4i2.242

required more than 6-6.5 mm in order to obtain a good implant placement result.[5,6] However, in some clinical cases, many cases of the missing tooth were found which conditions already impossible to install SDI due to thin buccal lingual bone conditions or short mesiodistal edentulous distances. Although in bone conditions that do not meet the standard of implant placement, horizontal bone augmentation can be done such as bone splitting, block bone grafting, and distraction osteogenesis, these techniques have procedures that are too complicated, prolonged treatment time, are quite expensive, and unpredictable complications that cannot be avoided.[7]

A treatment plan with NDI can be an alternative treatment in cases with inadequate bone volume both in the buccolingual and mesial-distal directions.[5] The term *narrow-diameter implant* or commonly called NDI has different size classifications in the existing literature, but in general the implant diameter is said to be less than 3.5 mm.[8] NDI began to be known in 1995, with the development of existing technology the use of NDI is increasingly popular.[9] However, the use of NDI does not have the same indication as SDI. Therefore, NDI has a specific indication in the form of limited mesiodistal space, for restoring mandibular incisors and maxillary lateral incisors.[10] There is still debate over the use of NDI, especially in the use of the posterior region and as a single or splinted crown.[7,10] NDI is expected to be applied more widely in prosthodontic treatment for elderly patients, and patients with inadequate soft and hard tissue support, so that can shorten the treatment sequence also costs incurred by patients.[6,7,10,11]

This scoping review assesses the uses of NDI in prosthodontic care. In addition, to see how the considerations, indications, and evaluation of the NDI placement supported various types of fixed denture restorations both for the anterior and posterior regions. Therefore, it is hoped that this scoping review can improve the understanding of dentists and as a basis for scientific evidence on the use of NDI in prosthodontics treatment.

METHOD

The writing was made as a scoping review based on the definition presented by Arksey & O'Mailey. The objective of this scoping review is to summarize and present the result of research that has been conducted about one part of certain topics or field science. The making of this scoping review was arranged in several stages, determining the question study, determining the type of relevant research, conducting a selection study, collecting data on a chart, and composing.[12]

The research question used in composing this scoping review is *what prosthodontics treatment can be done with a* NDI?. The defined population is subject with tooth loss and treated with NDI.

Search literature was carried out with an electronic search using PubMed, EBSCO, and Scopus. The search strategy uses these specialised terms: *(((small-diameter) OR (narrow)) AND (implant)) AND (restorations).* The search of the literature has been given several limitations published in 2017-2021, clinical studies in humans, also published in English. Inclusions and exclusions criteria used for selecting literature have been obtained and can be seen in table 1.

Independently screened all the titles and abstract that has been found and excluded studies for their irrelevance to the review based on the inclusion and exclusion criteria. Several literatures were eliminated due to the unavailability of full text and duplicated from the three search engines. Results of the collected information will be displayed in a table with relevant information such as the author's name, year published, objective, method, and conclusion.

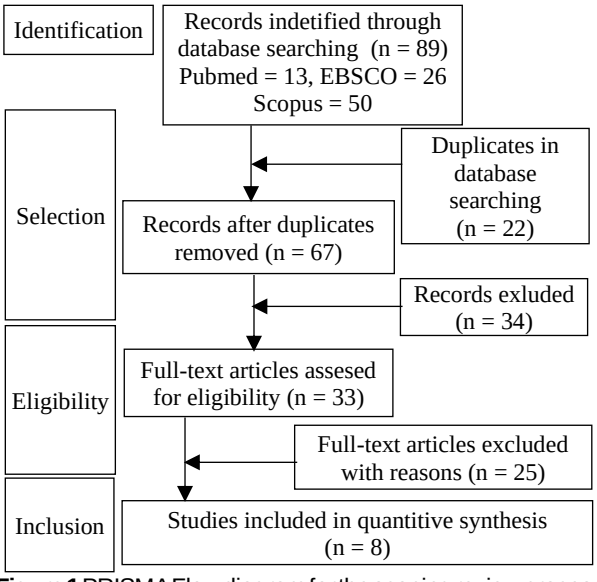

Figure 1 PRISMA Flow diagram for the scoping review process

Review of literature

The electronic search using keywords on Pubmed, EBSCO, and Scopus identified 89 articles. 22 articles are excluded because of duplication from the three search engines. Several articles were excluded due to irrelevance to the review based on inclusion and exclusion criteria. A full-text search of the entire remaining findings was conducted and read thoroughly. The remaining li-

DOI: 10.46934/ijp.v4i2.242

Table 1 Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Period	Published January 2017 – December 2021	Published before January 2017
Language	English	Non-english
Subject	Patients	Non-patients
Concept	Clinical evaluation and definitive restoration using NDI	Using non-NDI
Context	Reporting patient's clinical evaluation.	Not discuss the patient clinical evaluation.
Design	Randomized Clinical Trial, Retrospective Study, Prospective Study, Observational Study	Case report, Consensus Report

Table 2 Basic characteristics, objectives, methods, and conclusion included in the scoping review

No	Author (Year)	Objective	Method	Conclusion
1	Francesco Pieri, et al.(2017)[10]	The aim of this study is to compare 5 years outcome of NDI to SDI in supporting fixed partial denture in the posterior region (Prospective)	Evaluation on 107 patients after 5 years: 1. Prosthesis Failure 2. Implant Failure 3. Evaluation and biological complications 4. Major and Minor Prosthetics Complications	5 years evaluation study indicate that the survival rate of NDI was comparable to SDI in supporting Fixed Partial Denture in the posterior region, but the prosthetic complications in NDI were significantly higher than the SDI.
2	Stuart J. Froum, et al. (2017)[5]	Evaluation of peri-implant bone remodeling, healing of the soft tissue, aesthetic, also patient satisfaction on NDI loading (1.8mm – 2.4 mm) in the incisivus region. (Retrospective)	Evaluation on 19 implants in 14 patients after 3 – 14 years post-loading: *1. Bone Remodelling* *2.* Bone Loss *3.* Marginal recession *4.* Bleeding on Probing *5. Papila Index Score* (PIS) *6.* Patient Satisfaction	• No implant failure or prosthetic complications indicating a 100% survival rate and 84,2% success rate. • All patients reported being satisfied with the result. • Respectively there are 1,99mm and 1,84mm in mesial and distal bone remodeling. • There is bone loss on average of 0.14mm and 0.17mm on the mesial and distal bone sides.
3	Andreé Nilsson, et al. (2021)[13]	Restoration evaluation on the *single-tooth implant* with *one-piece yttria-stabilized zirconia abutment* in *narrow* (3,3 mm) and regular diameter implant controlled after 6 after loading in the anterior region. (Prospective)	Periodontal evaluation on 48 implants in 53 patients after 6 years of loading 1. *Bleeding on Probing* (BOP) and plaque index on the mesial and distal implant and adjacent tooth. *2.* Evaluation of *Marginal bone loss* (MBL) in 3-phase: - Baseline (prosthetic loading) - First control (about 20 months) - Final registration (about 54 months) *3.* Questionnaire function evaluation and aesthetic while final registration using Visual Analog Scale.	• There is no failure on the implant that concluded a 100% survival rate. • 3 changed restorations for another reason than failure. • 5 fracture of *internal one-piece zirconia abutment in 3.3mm NDI* • The majority of patients are very satisfied with the aesthetic and function of the implant restorations.

DOI: 10.46934/ijp.v4i2.242

`4	Pablo Galindo-Moreno, et al. (2017)[14]	To investigate the distance between NDI and adjacent teeth influence the marginal bone level up to 3 years of placement. (Prospective)	Evaluation on 3 years from 83 implants in 59 patients. 1. Marginal bone analysis based on radiograph on examinations in first examinations, implant placement, restoration delivery, 6 months, 12 months, 36 months output. 2. Distance between adjacent tooth and implant at the time of implant placement - *Narrow*: 3,2 – 5,54 mm - Reguler: 5,55 – 7,14 mm - *Wide*: 7,15 – 10 mm	• The current study confirms that there is no influence of distance between the implant and adjacent tooth in NDI. • But this study found less MBL occurred in narrower distance to adjacent tootth. • In this study, MBL changes in adjacent teeth were not significant.
5	Jun-Yu Shi, et al. (2018)[7]	Evaluation of the long-term survival, complications, peri-implant conditions, MBL, and patient satisfaction of FPD supported NDI in the posterior region (Retrospective)	Evaluation on 98 implants in 67 patients, 8 years follow up 1. Long-term survival rate calculated with Kaplan-Meier Survival Plots. 2. Peri-implant condition while 8 years follow up 3. Evaluation of MBL between baseline and follow-up in mesial and distal restorations. 4. Complications rate per implant per patient. Questionnaire function evaluation and aesthetic while final registration using Visual Analog Scale.	• NDI could be a predictable treatment alternative for the long term. • This study showed high survival rates, high patient satisfaction, acceptable complication rates, and also marginal bone loss could be achieved.
6	Saba Sameeh Ghazal, et al. (2019)[15]	NDI (3.3mm) Ti-Zr alloy implants with a chemically modified hydrophilic surface are not inferior in regard to crestal bone level compared to SDI (4.1mm) implants with the same material in a single crown on the anterior or posterior region. (RCT)	Periodontal evaluations on 47 patients in 1-year follow-up. 1. Crestal bone level change in ND and SDI while implant placement and implant loading (IP dan IL) 2. Success rate, survival rate, gingival recession, and patient satisfaction.	• There is no significant difference found in both periodontal evaluations indicating that NDI TI-ZR with a chemically modified hydrophilic surface is not comparable to SDI and can be used as an alternative treatment plan.
7	Peron Christian, et al. (2020)[6]	Evaluate within clinical and radiographic parameters, implant survival and success rate of single, narrow, immediately loaded implant (3.1 mm) placed in fresh extraction socket or healed socket in the anterior region (Prospective)	Evaluation after 2 years in 16 patients: 1. Implant success and survival rates. 2. Average MBL of healed and fresh socket. 3. Average Pink Esthetic Score (PES) within 1 year and 2 years follow-up. 4. The probing average on 2 years follow-up.	• NDI can be used with a provisional restoration as a minimally invasive treatment in healed sites with thin bone crest and for the presence of reduced interdental spaces. • Soft and hard tissue stability was achieved in a fresh extraction socket with immediate provisional restorations.
8	Bielemann AM, et.al. (2018)[11]	Compared the peri-implant health, implant stability, and concentrations of pro and anti-inflamatory cytokines in the peri-implant crevicular fluid (PICF) in mandibular edentulous patients under conventional loading (CL) and immediate loading (IL) in using NDI as a retainer of mandibular overdentures. (RCT)	Clinical evaluation on weeks 1, 2, 4, 8, and 12 months in 20 patients after surgery:: 1. Peri-implant condition 2. *Implant Stability Quotient* (ISQ) 3. Marker Inflammatory *Peri-implant Crevicular Fluid*	• Probing depth was better in the IL group, but there is no significant result for others. • Implant stability and marker inflammatory are more stabilized in the CL group.

DOI: 10.46934/ijp.v4i2.242

terature was studied thoroughly with the full-text version and it was obtained 8 articles. The flow of literature search used in this scoping review can be seen in Fig.1, while the results of the literature used in this scoping review can be seen in table 1.

RESULTS

The electronic search in the database Pubmed, Ebsco, and Scopus provided a total of 89 titles that were considered potentially relevant. There are 8 full-text that include in this study, such as four prospective, two retrospective, and two RCT. Participants that were included in the studies were 16-107 participants. The time of the study also variated 1-14 years. All the studies included partial edentulous either in the anterior or posterior region. Aspects that were used in the studies are the survival rate and success rate, periodontal aspect, also VAS questionnaire, and patient satisfaction.

DISCUSSION

First introduced by Brandemark, implant has been used for a long time, along with the development of the implant technology the uses of implant has widely indications. Nowadays, NDI are available in almost all implant brands and designed significantly for mesiodistal space less than 6 mm or space between the implant and the adjacent tooth or buccal lingual bone height is 2 mm.[5,6,9] Narrow interdental space, usually in the incisor and premolar regions, is one of the main indications for NDI, but after shorts and long studies, it has been indi-dicated for the other region also type of work.

Prosthodontic treatment is the final stage of dental treatment which include rehabilitation after all the pathological conditions are met. In SDI many pathological conditions are resulting in bone loss that needs to have another set of surgeries for the pre-prosthodontics treatment, but with a NDI, some surgeries can be avoided. The NDI would be beneficial to decrease the rate of bone augmentation for implant insertion, this can help elderly patients or patients with a medical risk factor to have reduced surgical invasiveness for implant placement. Also, there are concerns and restrictions against time-consuming treatments associated with complications and pain. For patients with systemic conditions or elderly patients, NDI can be one of the main alternatives if patients need an implant but without any pre-surgery, because NDI needs less space and bone volume so can be placed directly and resulting in shorter treatment time and reducing the risk of complications.[6,9,15]

As one of the alternative treatment plans, NDI certainly has advantages and disadvantages such as reported in in-vitro studies and finite-element analysis that overloading of NDI may result in peri-implant crestal bone resorption which will compromise the longevity and success of the treatment.[10] Bone thickness around the abutment or implant screw also increases the risk of fracture both for the implant fixture or screw.[7] However, in a retrospective study of NDI placement for splinted FPD in the posterior region, the success rate and marginal bone loss were comparable with SDI.[10] A 10 years retrospective study also indicated that single and splinted FPD both in the anterior and posterior region showed a reasonable success rate also a high patient satisfaction rate. This is due to the improvement in the material of implant fixture with Ti-Al-V alloy material used to manufacture NDI to increase fatigue resistance and biocompatibility.[9] Moreover, further research is needed to evaluate and predictable outcome of treatment using NDI in the molar region.[7]

This scoping review assesses the uses of NDI in prosthodontic care. Our scoping review identified consideration, indication, restoration, and evaluation of NDI. From the eight literatures that match the inclusion criteria, there are differences in study design, implant diameter size, restorative materials, and evaluation methods so there are possibilities that can lead to limited information and inconsistencies in the summary.

Judging from the research design in the seven selected literatures, there are four prospective studies[6,10,13,14], two retrospective studies[5,7], and two RCT studies[11,15]. Based on the size of the implant diameter used, there is literature that uses implants size 1.8-2.2 mm[5], 2.9 mm[115], 3 mm[8,12], 3.1 mm[6], dan 3.3 mm[7,13,15]. For restorative materials, some literatures do not specifically mention the restorative materials[5], there is literature using PFM[7,14,15], lithium disilicate[6,13], and there is literature that includes both materials.[10] In these eight literatures, some researchers evaluate only based on objective[6,10,11,14,15] also objective and subjective[5,7,13] from patients.

In a study conducted by Galindo et al on the implant placement of 83 NDI in 59 patients and evaluation every six months to 36 months in the maxillary and mandibular incisor regions, a 100% success rate was obtained with an average marginal bone loss of 0.0-0.50 mm in 36 months follow-up both in the anterior and posterior region. Distance from implant to adjacent tooth was counted narrow, regular, or wide but marginal bone loss was found to be less in the narrow distance. These re-

DOI: 10.46934/ijp.v4i2.242

sults are in line with the study conducted by Peron and Romanos in 16 patients with 16 NDI in the anterior region with a follow-up period of two years for both newly formed and healed sockets having a 100% success rate.[14]

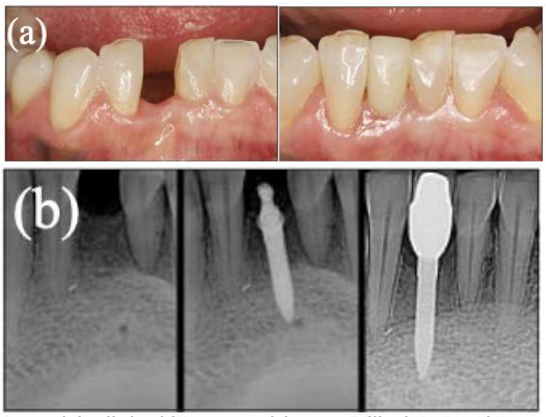

Figure 2(**a**) Clinical features of the mandibular anterior region before and after NDI placement with restoration follow-up for 6 years, (**b**) radiographic periapical before implant placement, immediate implant placement, and 6 years follow-up after restoration.[5]

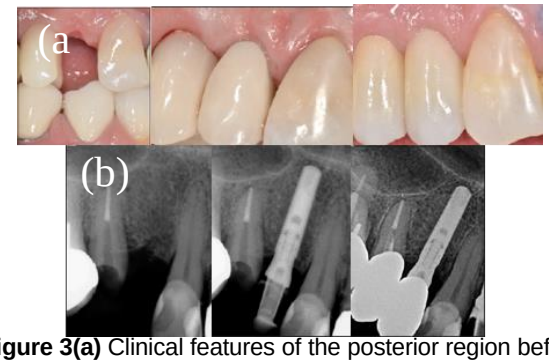

Figure 3(a) Clinical features of the posterior region before, during, and after insertion of the NDI with restoration follow-up after 2 years, (**b**) radiographs periapical before implant placement, during implant placement, and 2-year follow-up after restoration.[6]

Evaluation of the patient satisfaction obtained by Stuart et al, Nilsson et al, and Shi et al showed that most patients were satisfied with both the aesthetic and functional results resulting from the installation of NDI.[5,7,13] Study conducted by Stuart, et al of 14 patients reported bone remodeling with an average of 1.9 mm and 1.84 mm in the mesial and distal parts of the implant, and only 5 implants experienced bone loss but only 0.14 mm in the mesial and 0.17 mm distal to the follow-up period of 3-14 years.[5]

Nillson, et al also reported that 14 patients with 16 NDI had a 100% success rate despite 5 fractured restorations with one-piece zirconia abutments. Based on a study conducted by Shi, et al with a follow-up period of 8 years in 67 patients with 98 NDI it was found that both single and splinted restorations in the posterior region had a success rate of 96.9% at implant level and 97% at patient level. The mean MBL obtained was 1.19 mm at the implant level and 1.15 mm at the patient level, and only 8.5% of implants and 9.2% of patients had peri-implantitis; 89.2% of patients were satisfied with the aesthetics produced, this was in line with 84.6% of patients satisfied with the function obtained.[13]

In the study of the use of NDI in the restoration of the posterior region reported by Shi et al, also a similar study was carried out by Pieri et al reported 113 NDI in 49 patients compared to 126 SDI in 58 patients, there were 12 cases of prosthesis complications but only 2 cases of prosthesis complications in SDI. However, this is inversely proportional to marginal bone loss in NDI patients, only 36.7% experienced a bone loss of more than 1 mm, and 8.2% experienced more than 2 mm, this was quite far adrift in the SDI group who experienced more than 1 mm bone loss (43.1%) and losses above 2 mm (13.7%). Implant success rates at the 5-year follow-up period for the NDI were 99.1% and SDI 96.8%.[10]

In a study using titanium-zirconium alloy implant material by Ghazal, et al, similar results were also found. At one year follow-up, the success rate was 100%, crestal bone loss was only 0.27-0.34 mm and this figure was lower than the use of SDI with the same implant material, as well as in gingival recession and also satisfaction levels of patients did not differ significantly between SDI and NDI.[15]

A RCT conducted by Bielemann et al on 20 patients with edentulous mandibular. It was reported that 2 NDIs were installed in the anterior mandibular region as retention of the mandibular overdenture, 10 patients were carried out with the conventional loading protocol, namely MO installation 12 weeks after implant placement, and 10 patients underwent immediate loading with MO installation directly after implant placement. Obtained on the *immediate loading protocol* (IML) probing depth results are better than the *conventional loading* (CL). However, in the CL group, the implant stability was better and the number of inflammatory markers was lower. The other periodontal parameters were not statistically significant. In clinical results, both CL and IML showed good osseointegration in the use of NDI as a retainer for *mandibular overdenture*.[11]

In line with the scoping review question and objectives, there were limitations to the search to studies NDI in prosthodontics treatment. Most of the literature had a follow-up of less than 5 years, even for the mandibular overdenture supported by NDI, the follow-up was conducted only after 1 year. Further studies with longer follow-ups are needed to

DOI: 10.46934/ijp.v4i2.242

determine the long-term result of NDI as a prosthodontics treatment.

The other limitation is the lack of reports on using NDI as the supported FPD in the posterior region both in single and splinted crowns especially in the molars region. In a study conducted by Shi, et al even though there was the use of NDI in the molar region but the population was still less than in the premolar region. So that more research is needed to use NDI as an alternative option for supported single or splinted FPD in the molar region. For the last addition, the diameter of the NDI used in the scoping review is all in different sizes, so it is necessary to conduct further research on the use of the right diameter for each treatment plan.

In conclusion, our scoping review identified that a NDI has a reasonable clinical success rate in terms of periodontal health, marginal bone remodeling, restoration, and patient satisfaction, also it resembles a Standard-diameter implant's success rate in follow up 1-14 years. The NDI can be the main choice in supporting single FPD both in the anterior and posterior region with short mesial and distal distance because the distance between the implant and the adjacent tooth did not affect the marginal bone level resorption both in the implant or the adjacent tooth, and also NDI has the potential to be used as a retainer in mandibular overdenture both in the conventional loading and immediate loading.

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Stress distribution on denture-bearing areas with various thickness of soft denture liner using finite element analysis

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ABSTRACT
Denture-bearing areas in edentulism are unable to tolerate masticatory load because of severe alveolar ridge resorption, which decreases masticatory function in the stomatognathic system. Due to the cushioning effect, the use of soft denture liner (SDL) helps reduce the masticatory load placed upon the denture-bearing areas. The physical properties and thickness of SDL have an impact on the stress distribution and cushioning effect. The masticatory load will harm the alveolar ridge and lead to more severe resorption, when modulus elasticity of SDL lower than the mucosa. The stress distribution of the masticatory load can be analyzed more accurately in-silico study using finite element analysis (FEA) method. In this paper, the stress distribution in denture-supporting areas with various SDL thicknesses is evaluated using FEA. The thickness of SDL contributes to the distribution of stress upon the denture-bearing areas by minimizing the masticatory load. It is concluded that through the same modulus elasticity of the mucosa and SDL is able to equally distribute stress on the denture-bearing areas.
Keywords: stress distribution, denture-bearing area, soft denture liner thickness, finite element analysis

INTRODUCTION

The mastication system, which is one of the stomatognathic systems, is complex with various tissue structures that function simultaneously to produce a functional movement.[1] The mastication system in edentulous patients differs from that in dentulous patients due to resorption conditions and muscle hypotonus, so that it is unable to accept the mastication force and disrupt the functions of the stomatognathic system.[1] According to Riskesdas 2018 data, 29% of the Indonesian population aged 55-64 years old experienced edentulism, and the percentage of edentulous at the age of 65 years and over is 30.6%.[2] Edentulous treatment using complete denture (CD) with heat polymerized acrylic resin (HPAR) material is still often used because it can restore aesthetics, and the mastication function and price are affordable.[3,4] But over time of use, CD can cause effects on the alveolar and mucosal repellent to resorb and atrophy so that patients with this condition will feel pain when using CD and require more complex treatment.[4,5].

The use of soft denture liner (SDL) material can solve this problem because of the cushioning effect, so that the mastication load on complex supporting tissues can be minimized and reduced pain during mastication.[3,6-8] The use of SDL can distribute the mastication load more evenly on the denture-bearing area because the load is partially absorbed by the SDL material.[7] The cushioning effect of SDL material has shock absorption properties so that the voltage distribution can be spread evenly and the mastication load can be minimized, reducing the occurrence of resorption on alveolar linggir.[7,9,10] In some cases of CD and SDL use, there are complaints of pain. This is usually influenced by the thickness of the SDL material, which is not adequate.[11]

The physical properties, composition, and thickness of the SDL material affect the cushioning effect and stress distribution of the SDL against the denture-bearing area.[12] The thicker the SDL, the higher the elasticity.[10] The thickness of the SDL material that is effective in obtaining an optimal cushioning effect and distributing the voltage evenly is 2-3 mm.[9-11] If the use of SDL material is improper, there will be further resorbtion of linggir because when the modulus properties of the elasticity of the SDL material are lower than the mucosa, then the load distributed will be destructive.[10,12,13]

Some methods that can be used to assess the load from mastication to teeth or CD supporting structures are photoelasticity, strain measurement, brittle laquer, and finite element analysis (FEA),[3] that is able to provide information with non-specific properties both qualitatively and quantitatively that can be reproduced from the biomechanical characteristics of dentures and supporting structures without the need for ethical considerations. This method is one of the techniques that is widely used to estimate the load of dentures on supporting tissues and teeth.[3,14]

The purpose of this paper is to assess the stress distribution in the support tissues of dentures of different SDL thicknesses using FEA.

LITERATURE STUDIES

Complete edentulous

Edentulism is the state of being edentulous; with-

DOI: 10.46934/ijp.v4i2.207

out natural teeth, while edentulous is without teeth, lacking teeth.[15] In patients, the ability to accept the mastication load will decrease due to the presence of missing mastication components, such as the teeth and some supporting structures.[1,16] Therefore, edentulous patients tend to choose soft foods and avoid foods that tend to be harder, causing muscle hypotonus. Resorption of residual ridge continues to occur, which will have an impact on disturbances in each function of the stomatognathic system.[1,17,18]

One of the basic functions performed by the stomatognathic system is to collect and grind food, or so-called mastication. Mastication is considered to be the initial phase of food digestion in which the force occurs as a result of movement that interacts complexly between the muscular system, teeth, lips, cheeks, palate, the salivary glands, and temporomandibular joints.[19] In edentulous patients, the mastication system will undergo changes, causing the digestive process that occurs in the mouth to be disturbed, which results in disruption of nutritional intake.[17,18,20] The manufacture of dentures is one of the efforts made to overcome disturbances in the mastication system due to the loss of mastication components.[16]

Removable partial dentures (RPD), implant supported overdenture, and removable CD are some types of dentures that can restore the aesthetics and functionality of edentulous patients.[8,21] As time goes, alveolar bone resorption occurs continuously throughout life and is chronic, progressive, irreversible, and cumulative due to tooth loss.[22,23] However, bone resorption can also be affected by unfavorable mechanical conditions of the prosthesis, resulting in impaired adaptation and retention.[22] These factors can interfere with mastication performance, especially in patients with thin and atrophy mucosa.[22]

Once the patient is edentulous, remodeling of the residual ridge becomes progressive with more resorption in the first-year post-extraction.[24] Although the process of resorption from the alveolar ridge occurs progressively, the rate of this resorption varies from patient to patient. This condition is readily apparent clinically after tooth extraction, but the biology of this process is still not well understood.[25] However, there are several factors that may influence this, namely systemic factors such as the use of drugs, smoking, conditions that affect bone metabolism, and gender. As for the local factors, namely the use of CD and design errors of the CD, which can damage the supporting structure.[24]

Complete dentures

A CD is a fixed or removable dental prosthesis that replaces the entire dentition and associated structures of the maxillae or mandible.[15] The CD is made up of several parts, including a base, flange, border, and artificial teeth.[26,27] In rehabilitating edentulous patients, conventional CD with HPAR material is still the main option because this material has good aesthetics, similar to gingival, as well as easy laboratory procedures.[3,4] Acrylic dentures are also often called mucosal support removable dentures or soft tissue support dentures because the mucous membrane is the foundation or support of the denture.[14,28]

In edentulous patients with mucosa as denture support, it can cause denture instability due to the elastic properties of the mucosa during functional and parafunctional movements in the vertical and lateral or oblique directions. Movement in the lateral direction has the most damaging effect due to displacement of the denture so that the masticatory load is distributed unevenly over the denture-bearing area and there are areas that receive greater pressure than other areas.[1,16,29] When this happens continuously, the mucosa and alveolar bone will be damaged, so the denture base needs to be made as wide as possible and in close contact with the mucosa so that the masticatory load is distributed evenly.[16]

In edentulous patients, the distribution of the load received will change, because the load is not directed directly to the bone but only to the mucosal surface.[30] The oral mucosa has a physiological and mechanical capacity that is quite resistant to pressure because it is composed of epithelium and underlying collagen fibers.[30-33] However, when the mucosa receives too much pressure over a long period of time from the use of GTL, injury can occur to both soft and hard tissue, pain or discomfort, and further ridge resorption and atrophy, which will affect the usage of the denture.[14,21,24,30,35-38]

Although the use of conventional CD is successful in rehabilitating edentulous patients, it is different in edentulous patients with severe resorption of the ridge, the presence of mucosal atrophy, and sharp ridges.[8] This is due to the inability of the ridge to accept occlusal loads during mastication due to pain, so alternative treatment modalities are needed.[6-8,10-12] The alternative treatment that can be done is to line the CD base with a SDL, because this material can absorb the masticatory load and distribute it evenly to the denture-bearing area.[4,7] The SDL materials are also able to increase comfort in denture-wearing patients with atrophic

DOI: 10.46934/ijp.v4i2.207

ridges, thin and non-resilient mucosa, and bruxomania.[7]

Soft denture liner (SDL)

The SDL or called resilient denture liner is an interim (ethylmethacrylate with phthalate plasticizers) or definitive (processed silicone) liner of the intaglio surface of a removable CD, RPD, or intraoral maxillofacial prosthesis.[15] The term *soft liners* refers to the materials that are resilient and used to resurface the intaglio surface of denture bases that receive masticatory loads due to the shock-absorbing properties of these materials so that the load received by the mucosa can be absorbed and distributed evenly so as to reduce pain when the denture is functioning.[39,40]

The SDL are classified based on the term of usage and the type of material. Based on the term of use, it is divided into short-term and long-term. Short-term SDL is a material that is not recommended for more than 30 days of usage (temporary or interim). Short-term SDL is known as tissue conditioner, which is acrylic-based. As for long-term SDL materials, this material can be used for more than 30 days to a year (permanent). This type of long-term SDL also consists of a resin-based which consist of auto-polymerized and heat-polymerized. There is also an acrylic-based which also has auto-polymerized and heat-polymerized.[12,15,40-43]

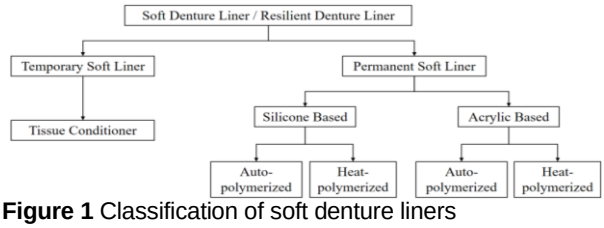

Figure 1 Classification of soft denture liners

In conditions with poor support or foundation (sharp, thin, and atrophic ridge anatomy) causing CD not able to adapt properly to the mucosa. So, when receiving the masticatory load, the CD becomes mobile and tilts, which makes the support area minimal. As a result, the pressure on the mucosa exceeds the average pain threshold limit, causing pain and discomfort in the patient. By lining with SDL material, it can solve the problem due to its nature to absorb stress (shock absorption) and distribute it evenly due to its viscoelasticity properties. The elastic properties of the SDL material on the CD base will increase the contact surface of the denture so that the stress from mastication can be evenly distribute and reduce pain.[7,9,44]

Although the use of SDL material can help overcome these problems by minimizing the masticatory load and reducing pain due to its elastic properties or cushioning effects.[7,9,10] There are still some CD patients with SDL who complain of pain. This is usually caused by the thickness of this material, which is not adequate.[11] The elastic properties of the SDL material are influenced by the thickness, as well as the hardness and modulus of elasticity of the material itself. Because SDL materials and oral mucosa are in essence of two compression springs in series, when SDL materials have higher elasticity than oral mucosa, the majority of the load exerted can be absorbed more and result in a smaller displacement.[10] It can be said that the thickness of the SDL material plays an important role in the distribution of the stress received by the denture-bearing area.[7] The stress distribution of mastication on teeth or supporting structures of CD can be determined by photoelasticity, strain measurement, brittle lacquer, and finite element analysis (FEA).[3]

Finite element analysis

The FEA is a numerical method to obtain an accurate solution to a problem by simulating modeling for later analysis.[45,46] This method was originalnally developed and used in the field of engineering to be a solution to complex physics and engineering problems due to a series of very complicated stages. This development of FEA allows modeling construction to be carried out quickly and effectively, thus playing an important role in the field of engineering.[47]

The use of FEA in the field of medicine has become a testing tool that has developed significantly, especially the use of biomechanical analysis in living things, because it is non-invasive and easy to repeat without the need for duplication.[48] In addition, modeling and treatment can be determined freely as desired, diverse elements can also be combined, the testing process is carried out in one program, and the resulting modeling also has conditions that are identical to the original.[45]

Developments in the field of radiography, such as CT and MRI, make FEA popularly used in the field of dentistry, as it accurately obtains the geometry of bones, both their quality, quantity, and shape.[46.47] The use of FEA in dentistry is, for example, in implants, obturators, restorations, periodontal ligaments, and trauma and fractures.[49-57]

DISCUSSION

The CD with SDL material is one of the good treatment options to overcome the problem of edentulous patients with severe ridge resorption (flat or

DOI: 10.46934/ijp.v4i2.207

sharp ridges) with a thin, non-resilient layer of mucosa that will cause pain to the mucosa when receiving mastication from the denture.[6,7,40,58] The use of SDL has been widely reported and clinically proven. In a RCT clinical studies, it was also found that the use of SDL increased the mastication ability.[6]

The SDL are classified into several types based on their duration of usage as well as acrylic-based or silicone-based with different viscoelasticity properties of each material.[9,12,58,59] Murata et al, suggest that silicone-based SDL should be first applied to the denture because of its better durability and even though the cushioning effect is lower than that of SDL acrylic. If the patient still feels pain or discomfort, the silicone-based SDL can be replaced with acrylic-based due to the better cushioning effect of this material. Keep in mind, however, that acrylic-based SDL must be replaced on a regular basis due to its material properties and durability being not as good as silicon-based.[42]

The elastic properties of SDL materials are influenced by hardness, modulus of elasticity, and their thickness.[11] However, it is also necessary to pay attention to the mucosa thickness, denture adaption, and arrangement of artificial teeth, as well as the number and direction of the masticatory load, because they affect the amount of the load received by the denture-bearing area.[58] Ideally, a thickness of 2-3 mm SDL is required to obtain an optimal cushioning effect.[9,11] In some studies, it is said that the 3 mm thickness of the SDL material provides optimum resilience, but more than that, it will affect these properties.[12,60] In their research, Murata et al,[42] stated that the most effective thickness of the SDL material is 1.5-2 mm. Lima et al,[13] from FEA results found that the ideal thickness of the SDL material was 2 mm. When the SDL thickness is less or more than ideal, the stress will be greater on the denture-bearing area. This result is also supported by the research conducted by Hussein[2] and Bacchi et al.[61]

However, this is different from what Radi et al,[43] found from the FEA results. The SDL material with a thickness of 2-4 mm reduces the load received by the overdenture implant to the denture-bearing area as the thickness of the SDL material increases. This finding is in agreement with what Santos et al,[62] found from the FEA results. It can be seen that SDL material with a 3 mm thickness provides a more minimal stress on the denture-bearing area than a thickness of 1.5 mm. So, it can be said that increasing the thickness of SDL also increases the cushioning effect of the material itself. However, according to Sato et al,[10] from the FEA results, it was found that the thickness of the SDL material did not play a role in stress distribution. Therefore, to obtain an optimal cushioning effect, we do not always have to choose the most resilient SDL material (low modulus of elasticity).[10] However, when the SDL material has a lower modulus of elasticity than the mucosa, the stress received is not evenly distributed.

The same result was also stated by Shim and Watts, who used the FEA study to look at the stress distribution in CD with SDL, showing that the modulus elasticity of SDL should be the same as with mucosa because SDL material is used to compensate for the loss of thickness of the mucous layer.[10,58,61] The thickness of the soft tissue was also found to not affect the accepted stress ratio, so it is not recommended to use this material with excessive thickness as it can weaken the denture base,[58] despite the fact that the thicker the material, the greater its elasticity. However, that's not always the right choice.[10]

Therefore, the use of SDL materials with an improper thickness will lead to further resorption of the ridge. Due to the lower modulus of elasticity of SDL material than the mucosa, the load will harm the denture-bearing area.[10,12,13] The physical properties, composition, and thickness of the SDL material play a role in the cushioning effect and stress distribution of the SDL material against the denture-bearing area.[13] It is important for clinicians to find out the ideal thickness of the SDL material for distributing the stress evenly to the denture-bearing so that the properties of the SDL material can be utilized optimally.

It is concluded that the use of SDL material of an appropriate thickness is able to distribute the stress evenly to the denture-bearing area and reduce pain during mastication through the same modulus of elasticity between SDL and mucosa.

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DOI: 10.46934/ijp.v4i2.207

The effect of surface treatment of polymethyl methacrylate denture base on the soft-liner bond strength

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ABSTRACT
The increased use of removable denture in elderly population are followed by the increased use of soft liner for denture reline due to bone resorption. However, soft liners are found to be bonded poorly to polymethyl methacrylate (PMMA) denture base. Thus, several methods are developed in order to improve the bonds between denture base and soft liner, i.e., mechanical methods (sandblast, sandpaper, laser), chemical methods (MMA monomer, acids, acetone, and plasma), or combination of both. This article evaluates the effectiveness of various surface treatment methods of PMMA materials in improving the bonds with silicone or acrylic-based soft liner. It is concluded that surface treatment on the PMMA in general increase the bond strength with the soft liners compared to the control group; the use of Er:YAG laser and MMA monomer show the highest bond strength between the PMMA and soft liner materials. Several factors such as the duration of treatment and the laser intensity energy may affect the bond strength between PMMA and soft liner. Acrylic-based soft liner in general shows better bond strength than silicone-based soft liner, nevertheless both materials show improvement in bond strength with PMMA after surface treatments.
Keywords: polymethyl methacrylate, soft liners, surface treatment, bond strength

INTRODUCTION

The increasing number of elderly populations correlates with the increasing use of dentures due to edentulism. Conventional removable dentures made of polymethyl methacrylate (PMMA) are still widely used because they are relatively inexpensive and the treatment procedures are less invasive than fixed denture treatments. However, the use of removable dentures is often accompanied by jaw bone resorption due to excessive load and this condition may cause the denture to become loose when worn by the patient. Furthermore, these ill-fitted dentures also cause irritation and injury to the oral mucosa. To overcome this problem, relining the denture base with a soft liner is often performformed to avoid excessive load on bones.[1,2]

A soft liner can be defined as a soft (viscoelastic) material that used as a way to distribute the functional load of a denture more evenly so that the concentration of the load at one point on the mucosa can be avoided.[3,4] Soft liners can be divided into short-term (tissue conditioner) and long-term soft liners. Several articles concluded that long-term soft liners can last for about 3-6 years.[3,5] Soft liners can also be classified as heat-polymerized or auto-polymerized soft liners; heat-polymerized material, whether silicone or acrylic, is recommended as it is more stable and has better durability.[4]

Silicone or acrylic soft liners have advantages and disadvantages; for example, silicone material has a good elasticity but bonds poorly with the denture base, causing it to easily come off. On the other hand, the acrylic soft liner easily loses its elasticity over time but this material bonds very well with the PMMA. Thus, no material is truly superior as a soft liner, namely a good resilience/flexibility, may last for a long time, and bonds optimally with the PMMA denture base.[6-9] Adequate bonding between soft liner and PMMA is very important because poor bonding may result in a space formed between the two materials, which it be a potential site for microorganism growth and overall soft liner failure.[10] In addition, the plasticizers contained in the material may be released over time from the soft liner, causing the material to become harder.[11-13]

Several methods have been developed to improve the bond between the PMMA denture base and the soft liner, especially for silicone materials.[1] Modification of the denture base surface, either mechanical or chemical, often used as a way to increase the contact surface area with the soft liner and thus improving the bond.[14] The mechanical surface treatment methods of the PMMA can be performed through sandblasting, sandpaper, or a laser.[3,12,15] Meanwhile, the chemical surface treatment may use either monomer, phosphoric acid, acetone, or modifying the PMMA structure with plasma.[6,15,17]

Science related to soft liners continues to develop, especially in the effort to increase the bond strength with a removable denture base. Several studies show that the bond of silicone material with acrylic resin is still below the acrylic soft liner material even when adhesives have been applied to

DOI: 10.46934/ijp.v4i2.243

the denture base material.[6,14] Thus several methods have been developed to improve the bond strength between soft liner and PMMA, especially for the silicone material.[6,12,19] The purpose of this review is to evaluate the effectiveness of various PMMA surface treatment methods in increasing the strength of the bond with soft liner materials. Through this scoping review, it is hoped that the clinicians will understand various methods to increase the bonding between soft liners and denture base and be able to choose the best surface treatment method.

LITERATURE STUDIES

This paper is written as a scoping review that follows the Arksey's staging framework and the *preferred reporting items for systematic review extension for scoping review* (PRISMA-ScR) guidelines.[20,21] As previously mentioned, the scope of this paper discusses the bond strength between soft liner and PMMA after surface treatment. A scoping review composition starts with determining the topic questions and establishing the *population*, *concept*, and *context* of the topic. The topic question is *How does the surface treatment of denture base material on the bonding strength of the soft liner?* The population will be denture base material that is relined by a soft liner. The concept determined is the surface treatment of the denture base material, with the bond strength between the denture base and the soft liner determined to be the context in this paper.

The literature relevant to the research questions in this scoping review was searched using the internet. Two source databases were used: PubMed and EBSCOhost. The keywords were ("*Denture*" AND "*Surface Treatment*" AND "*Soft Liner*" AND "*Bond Strength*"). The articles will follow a set of inclusion and exclusion criteria that are listed in Table 1.

The literature search was performed on PubMed and EBSCOhost databases yielded a total of 28 articles, of which 15 articles were obtained from PubMed and 13 articles from EBSCOhost. Duplicated literature from both sources was checked; 8 articles were excluded and left a total of 20 articles. Furthermore, 4 articles were irrelevant to the topic question and thus also excluded from this review. The remaining articles were then checked for the inclusion and exclusion criteria that have been set for this scoping review by reading the full-text articles; 5 articles did not meet the requirements. The final screening results gave 11 articles that will be reviewed in this scoping review.

A summary of the results of the articles used in this paper; table 2 presents the demographic data of the articles while table 3 presents the testing methods, surface treatment groups and research results. All research articles used in this scoping review are in vitro studies, of which 9 studies are designed as cross-sectional studies and 2 studies are designed as prospective studies. All studies used a universal testing machine (UTM) for testing the bond strength between PMMA material and soft-liner material.

DISCUSSION

This scoping review aims to summarize the results of existing studies regarding the comparison of various methods of surface treatment of acrylic resin base material on the bond strength of soft liners. The articles shown in this paper are all in vitro studies using heat-cured PMMA specimen blocks as research samples. Of 11 articles discussed in this paper, 9 articles are cross-sectional studies and 2 articles are prospective studies with a follow-up period of 24 hours, 1 week, or 1 month.[11,12]

Based on the 11 articles, several variations exist, namely the surface treatment methods, soft liner types, and the testing machine speed. Different types of soft-liner were used in the studies: seven studies used silicone, three studies used silicone and acrylic soft liner[3,6,14], and one study used acrylic soft liner.[12] Various surface treatments were also observed: particle sandblasting, MMA monomer, laser, plasma, acid etching, sandpaper, or combination method. Furthermore, the Universal Testing Machine (UTM) used in the studies performed with varying speed; 8 studies used 5 mm/min, 2 studies used 20 mm/min[3,14], while 1 study used 10 mm/min.[15] Those differences may have caused a variety in the results shown above.

The sandblasting method was the most studied method among all surface treatment methods (10 studies). All studies used aluminum oxide (alumina)

Table 1 Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Articles published from January-September 2021	Published before January 2011, languages other than English.
English articles	Case reports, finite element analysis (FEA) studies, systematic reviews, meta-analyses, clinical trials, or literature reviews articles.
Articles that are available as full text	Articles that do not have a full-text version
Articles in the form of in vitro studies	
Articles that discuss the bond strength between soft liners and PMMA denture bases that have been surface treated.	

DOI: 10.46934/ijp.v4i2.243

Table 2 Demographic data of the included studies

No	Author (Year)	Research Purpose	Samples
1	Swapna (2016)[3]	To evaluate the effect of various surface treatments of the PMMA on the soft liner bond strength (silicone and acrylic).	120 PMMA specimens divided into control group and 3 treatment groups. Soft liners (@ 40 specimens): Heat-polymerized silicone soft liner & Auto-polymerized acrylic soft liner 1 & 2
2	Surapaneni (2013)[7]	To compare and evaluate the bond strength between silicone soft liners and PMMA surfaces that have been mechanically or chemically treated.	80 PMMA specimens divided into control group and 3 treatment groups. Soft liners (@40 specimens): Auto-polymerized silicone soft liner 1 & 2
3	Haghi (2019)[6]	To compare the bond strength between 3 types of soft liners against PMMA materials and the comparison between the control group and the treatment group.	165 PMMA specimens for the control group and 4 treatment groups. Soft liners (@ 55 specimens): Heat-polymerized silicone soft liner 1 & 2 & Heat-polymerized acrylic soft liner
4	Atsu, Keskin (2013)[1]	To investigate the effect of alumina and silica sandblasting, silanization, and adhesives on the bond strength between soft liners and acrylic resin.	50 PMMA specimens divided into control group and 4 treatment groups. Soft liner: auto-polymerized silicone soft liner (@ 10 specimens).
5	Nakhaei (2016)[19]	To evaluate the effect of surface treatment of PMMA materials on the bond strength of silicone soft liner.	96 PMMA specimens divided into control group and 3 treatment groups. Soft liner: auto-polymerized silicone soft liner (@ 24 specimens).
6	Mempally (2018)[12]	To evaluate the mechanical, chemical, and mechanochemical surface treatment of PMMA on the bond strength of acrylic-based soft liners.	320 PMMA specimens divided into control group and 3 treatment groups. Soft liners (@ 160 specimens): Heat-polymerized acrylic soft liner 1 & 2
7	Gundogdu (2014)[17]	To evaluate the effect of different surface treatments on the bond strength of 2 different soft liners to acrylic resin material.	96 PMMA specimens divided into control group and 5 treatment groups. Soft liners (@ 48 specimens): Heat-polymerized silicone soft liner & Auto-polymerized silicone soft liner
8	Yildirim (2020)[15]	To evaluate the effect of argon plasma and Er:YAG laser treatment on PMMA surface on the bond strength between silicone soft liners and PMMA.	60 PMMA specimens divided into control group and 2 treatment groups. Soft liners (@ 30 specimens): Heat-polymerized silicone soft liner & Auto-polymerized silicone soft liner
9	Akin (2011)[16]	To investigate the effect of various surface treatments of PMMA material on the bond strength of the soft liner.	120 PMMA specimens divided into control group and 7 treatment groups. Soft liner: heat-polymerized silicone soft liner (@ 15 specimens).
10	Khanna (2015)[14]	To evaluate the bond strength between 2 types of soft liners with PMMA surfaces that have been treated with various methods.	60 acrylic resin specimens divided into control group and 2 treatment groups. Soft liners (@ 30 specimens): Auto-polymerized silicone soft liner & Heat-polymerized acrylic soft liner
11	Philip (2012)[11]	To evaluate the effect of various surface treatments of the PMMA materials on the bond strength of the soft liner	49 PMMA specimens were divided into control group and 6 treatment groups. Soft liner: auto-polymerized silicone soft liner (@ 7 specimens).

Table 3. Evaluation of bond strength based on various surface treatments

No	Author & Year	Testing Method	Treatment Method (number of samples)	Results & Summaries
1	Swapna (2016)[3]	UTM at 20 mm/min	1. Control group (30) 2. Alumina particles sandblasting 30s: ● 50µ (30) ● 150µ (30) ● 250µ (30)	1. 4.37, 6.89, 8.37 (kg/cm^2) 2. 3.07-**3.36**, 4.81-**5.20**, 5.13-**5.84** (kg/cm^2) All treatment groups showed lower bond strength than the control group. Heat-polymerized silicone soft liner showed the highest bond strength
2	Surapaneni (2013)[7]	UTM at 5 mm/min	1. Control group (20) 2. 250µ alumina particles sandblast (20) 3. MMA Monomer 180s (20) 4. Acetone 30s (20)	1) 0.480; 2) 0.435; 3) 0.853; 4) 0.541 (N/mm^2) MMA monomer significantly increased the bond strength of the soft liner than the control group and other treatment groups. Sandblasting decreased the bond strength between 2 materials.
3	Haghi (2019)[6]	UTM at 5 mm/min	1. Control group (33) 2. Er:YAG laser (200 mJ, 10 Hz, 10 sec) (33)	1) 2.5-**7.0**; 2) 1.9-**6.0**; 3) 0.7-**4.8**; 4) 3.1-**8.1**; 5) 1.2-**7.9** (MPa)

			3. 150µ alumina sandblasting 10s (33) 4. MMA Monomer 180s (33) 5. Phosphoric acid 30s (33)	MMA monomer showed the highest bond strength compared to control or other treatment groups. All other treatments lowered the bond strength. Acrylic soft liner showed the highest bond strength.
4	Atsu, Keskin (2013)[1]	UTM at 5 mm/min	1. Control group (10) 2. 50µ alumina sandblasting 15s (10) 3. 30µ silica sandblasting & silanization (10) 4. Silica sandblasting & adhesives (10) 5. Silica sandblasting w/ silanization & adhesives (10)	1) 1.35; 2) 0.28; 3) 0.34; 4) 0.91; 5) 1.01 (MPa) Surface treatment of the acrylic resin with silica-modified sandblasting and silanization showed lower bond strength compared to the control group (default adhesive).
5	Nakhaei (2016)[19]	UTM at 5 mm/min	1. Control group (24) 2. 110µ alumina sandblasting 10s (24) 3. Er:YAG laser (300 mJ, 10 Hz, 20s) (24) 4. Combination of laser and sandblast (24)	1) 0.9; 2) 1.29; 3) 1.24; 4) 1.36 (MPa) All treatment groups showed higher bond strength than the control group. Combination of laser and sandblast showed the highest bond strength.
6	Mempally (2018)[12]	UTM at 5 mm/min	1. Control group (80) 2. MMA monomer 10s (80) 3. 250µ alumina sandblasting 30s (80) 4. MMA monomer and sandblasting (80)	1) 0.41-0.51; 2) 0.84-0.89; 3) 2.81-3.50; 4) 2.03-2.39 (MPa) All treatment groups showed significantly higher bond strength than the control group. The mechanical treatment group showed the highest bond strength.
7	Gundogdu (2014)[17]	UTM at 5 mm/min	1. Control group (16) 2. 36% Phosphoric acid 30s (16) 3. Er:YAG laser (150 mJ, 10 Hz, 60s) (16) 4. 50µ alumina sandblasting 10s (16) 5. Combination of acid and laser (16) 6. Combination of acid and sandblast (16)	1) 0.2-**1.32**; 2) 0.36-**1.39**; 3) 0.21-**1.29**; 4) 0.09-**0.98**; 5) 0.32-**1.08**; 6) 0.22-**1.08** (MPa) Only phosphoric acid treatment increased the bond strength of the soft liner compared to the control group. All other groups showed lower bond strength. Heat-polymerized silicone soft liner showed higher bond strength than auto-polymerized liner.
8	Yildirim (2020)[15]	UTM at 10 mm/min	1. Control group (20) 2. Argon plasma (13.56 MHz, 1 min) (20) 3. Laser Er:YAG (300 mJ, 10 Hz, 20s) (20)	1) 0.38-**0.81**; 2) 0.60-**1.15**; 3) 0.69-**1.33** (MPa) Argon plasma and Er:YAG laser showed higher bond strength between the soft liner and PMMA than the control group. Heat-polymerized silicone soft liner showed higher bond strength than auto-polymerized soft liner.
9	Akin (2011)[16]	UTM at 5 mm/min	1. Control group (15) 2. 50µ alumina sandblasting 10s (15) 3. Er:YAG laser (200 mJ, 10 Hz, 20s) (15) 4. Nd:YAG laser (100 mJ, 15 Hz, 30s) (15) 5. KTP laser (100 mJ, 10 Hz, 60s) (15) 6. Sandblasting and Er:YAG laser 7. Sandblasting and Nd:YAG laser 8. Sandblasting and KTP laser	1) 25.25; 2) 21.04; 3) 32.73; 4) 23.43; 5) 23.53; 6) 23.82; 7) 17.66; 8) 18.26 (N/mm^2) Er:YAG laser treatment showed the highest bond strength compared to the control or other treatment groups. Other laser mediums and sandblasting method lowered the bond strength.
10	Khanna (2015)[14]	UTM at 20 mm/min	1. Control group (20) 2. 250µ alumina sandblasting (20) 3. MMA Monomer 180s (20)	1) 18.27-**18.82**; 2) 18.76-**27.42**); 3) 23.82-**32.74** (MPa) All treatment groups showed higher bond strength than control group. MMA monomer provided the highest bond strength. Acrylic soft liner showed higher bond strength than silicone soft liner.
11	Philip (2012)[11]	UTM at 5 mm/min	1. Control group (7) 2. Acetone 30s (7) 3. MMA Monomer 180s (7) 4. 1000 grit silicone-carbide sandpaper 5s (7) 5. 50µ alumina sandblasting 5s (7) 6. Sandpaper and MMA monomer (7) 7. Sandblasting and MMA monomer (7)	1) 0.1; 2) 0.12; 3) 0.11; 4) 0.12; 5) 0.12; 6) 0.11; 7) 0.14 (MPa) All treatment groups showed higher bond strength than the control group. The combination of sandblasting and MMA monomer treatment showed significantly higher bond strength than other surface treatment methods.

DOI: 10.46934/ijp.v4i2.243

particles in the sandblasting process and one study[1] mixed silica particles with the alumina particles. Only 4 studies found that the sandblasting method increased the bond strength between the soft liner and PMMA[11,12,14,19] and one study[19] even showed that there was no significant difference with another treatment group. Mempally et al showed that the surface treatment of the acrylic resin using the 250 µ particle sandblasting showed a significantly higher bond strength than the control group and other treatment methods; it was also showed that the PMMA surface with this treatment method gave the highest roughness.[12] This result is similar to the study by Khanna et al and Usumez et al; they demonstrated that the use of 250 µ alumina particle sandblasting showed greater bond strength than the control group, although the difference was not significant.[14,23]

In contrast, other studies showed contradicting results[3,6,17], which can be explained by how the sandblasting method worked on the PMMA surface. Sandblasting create microporosities on the surface, increasing the contact surface area between the PMMA and the soft-liner material, and thus increasing the bond strength. However, it is also known that this may also cause surface irregularities that lead to the failure of penetration of the soft liner material, causing air voids to form between the two materials and decreasing the bond strength, increasing the risk of failure.[6,16,17] The results is supported by Sarac et al, stating that sandblasting showed greater microleakage than the control group.[22] In addition, the sandblasting method may create stress at the interface junction between the PMMA and soft liner material, which is predicted to weaken the bond strength between the two materials.[1,16] Modifying the particles also did not improve the bond; Atsu and Keskin found that silica modification and silanization process was not effective in increasing the bond strength between PMMA and soft liner.[1]

Thus, the sandblasting results remain inconcclusive. It may be because this method is unpredictable in modifying the PMMA surface as the process cannot be fully controlled aside from determining the particle size and the treatment duration. It is nearly impossible to accurately control how deep the microcavity formed by the particles and thus increasing the possibility of uneven contacts between the soft liner and PMMA.[1,6,16]

Mechanical treatment can also be done by using sandpaper. Only one study discussed the use of sandpaper as a surface treatment method, showing that sandpaper significantly increase the bond strength of PMMA with soft liner compared to the control group, albeit still under the sandblasting method.[11] Due to this, it is difficult to conclude about the effectiveness of using sandpaper in increasing the bond strength.

Chemical surface treatment is another method to increase the bond strength between soft liner and PMMA. Chemicals such as MMA monomers, phosphoric acid, or acetone were discussed in several studies. Among these three materials, the use of MMA monomer is the most surface treatment method discussed in the studies. All studies on MMA monomer showed an increase in the bond strength between PMMA and soft liner. They also showed that MMA monomer was the treatment method that provided the greatest bond strength increase compared to other chemical methods.[6,7,14] This increase was thanks to the formation of surface microporosity through the etching process, increasing the surface area of contact between soft liner and PMMA.[7] Haghi, et al also found that the PMMA surface was cleaner and smoother than the control group and the treatment groups through *scanning electron microscopy* analysis, reducing any probability of air voids formed between the two materials.[6] Sarac et al also showed that MMA monomer provided the least microleakage compared to the mechanical (sandblasting) and chemical (acetone) treatment groups and increased the bond strength between acrylic resin and soft liner compared to the control group.[22,24]

Chemical surface treatment can also be done with phosphoric acid or acetone. There are only 2 articles reviewed that discussed the use of phosphoric acid[6,17] and acetone[7,11] for the treatment of PMMA surfaces, respectively. Phosphoric acid or acetone has the same mechanism as the MMA monomer mentioned above. Nevertheless, phosphoric acid and acetone were not very effective in improving the bond strength between the PMMA and the soft liner compared to the MMA monomer. Especially for phosphoric acid, the bond strength between the PMMA and the soft liner were lower than the control group.[6] However, Gundogdu et al showed slight difference in result; phosphoric acid etching showed a slight increase in the bond strength compared to the control group.[17] The result differences between two studies could be due to differences in the method of specimen preparation before the test was conducted as the former carried out a thermocycling process on the specimens, changing the physical properties of the two materials before the test was performed.[6]

The use of a laser can also modify the PMMA

surface. In this scoping review, the mediums used in the studies were Er:YAG (erbium-doped yttrium aluminum garnet), Nd:YAG (neodymium-doped yttrium aluminum garnet), and KTP (potassium-titanyl-phosphate), although of the three mediums used, Nd:YAG and KTP mediums were only discussed in one article.[16] Different results were observed from all article regarding the bond strength between PMMA and soft liners. Three studies[15,16,19] showed that significantly higher bond strength was observed in the Er:YAG laser treatment group compared to the control group, although one study[19] also noted that the laser treatment bond strength was not significantly different from the other treatment methods.

In contrast, two studies[6,17] found that the use of Er:YAG laser decreased the bond strength between the two materials when compared to the control group, although it was also noted that this decrease was not significant.[17] Also, one study that used Nd:YAG and KTP medium showed that they were not effective in increasing the bond strength.[16]

Laser treatment modifies the PMMA surface by forming microcavities that will increase the contact surface area with the soft liner. The cavities size is influenced by the laser energy intensity, treatment duration, frequency, and the medium used.[15,16] One study[6] that found a decreased bond strength with laser treatment used a lower energy intensity and shorter time (200 mJ, 10s) than the other studies[15,16,19] that showed a higher bond strength with the use of laser (200-300 mJ, 20s). It is predicted that higher laser energy intensity and/or longer duration of time could result in better bond strength between PMMA and soft liner. It would also explain why Nd:YAG and KTP laser showed a lower bond strength than the control group as only 100 mJ of energy intensity was used.[16]

Yildirim et al also discussed the use of plasma argon as a surface treatment method aside from the use of laser. They found that although not as effective as laser, plasma argon significantly increased the bond strength compared to the control group.[15] Plasma is claimed to increase the PMMA surface wettability, meaning that it increases the hydrophilic properties of the polymer surface without disturbing its mechanical properties, thus improving the adhesion.[15,25] However, it should be noted that as there is only 1 article that discuscusses the use of plasma in this review, so it may be inadequate to conclude whether the use of plasma is truly effective in increasing the bond strength between acrylic resins and soft liner.

Combination of two different surface treatment methods were also discussed in several studies. Combination of laser and sandblasting[16,19] and combination of chemical (MMA monomer) and mechanical (sandblasting or sandpaper) surface treatment on the bond strength between PMMA and soft liner were discussed.[11,12] This combination method gave varying results. Laser and sandblastting combination showed the highest increase in bond strength compared to the control or other treatment groups in one study.[19] However, other study[16] showed a lower bond strength compared to the control group although the difference was considered insignificant. This difference in results is possibly due to the difference in the sandblast particle size and the laser energy intensity used between the two studies. The combined use of laser and sandblasting may be effective in increasing the bond strength between acrylic resin and soft liner as long as the particle size, laser energy intensity, and duration of treatment are taken into account.

On the other hand, the combination of chemical and mechanical surface treatment methods was discussed in two studies.[11,12] Both showed that the method was effective to increase the bond strength between PMMA and soft liner. It worked through the combination of microporosity formation and also depolymerization of the PMMA surface, thus more optimal bonding between the two materials is achieved.[11] However, it was also noted that this mechanochemical method still showed a lower bond strength compared to the sandblasting method, possibly due to uncontrolled pressure appled during MMA monomer application, damaging the PMMA porous surface.[12]

Different soft liners also affect the bond with PMMA. Generally, the bond of acrylic soft liners with PMMA better than silicone soft liners regardless of the surface treatment method used.[6,14] Despite better elasticity and longer duration of use, silicone bonds with acrylic resin through weaker adhesion forces (with the help of adhesives). In contrast, acrylic soft-liner bonds with PMMA through cohesive forces and is thus more resistant to shear forces that cause the detachment of soft liner from the acrylic resin.[12,19] Nevertheless, both materials generally had higher bond strength after the PMMA surface treatment than the control group. Also, heat-polymerized silicone soft liner bonded better with PMMA than the auto-polymerized ones.[6,15,17] These results are also in agreement with the study by Kulak-Ozkan et al, stating that auto-polymerized material tends to have greater shrinkage and shorter duration of use.[26]

As additional information, while it was not shown

DOI: 10.46934/ijp.v4i2.243

in the results summary, two studies[11,12] also observed the effect of immersion on the specimens' bond strength. It was conducted to simulate a real-life situation, where a soft liner may lose its elasticity and undergo dimensional changes due to water/saliva absorption, thus affecting the bond with PMMA.[6,12,17] Specimens immersion after 1 week gave the highest bond strength in one study. It may occur due to the latent polymerization of the soft liner during the immersion period and thus the improving the bond between the liner and PMMA. Also, it was observed that the bond strength decreased after immersion for 1 month.[11] This is also supported by Mempally et al that showed 24 hours of immersion provided higher bond strength than the 1-month immersion period. However, they use acrylic soft liner in the study and these different properties may also affect the process.[12]

The limitations of this scoping review are related to the variations in the details of the treatment used as mentioned above. This lack of uniformity in the treatment methods and materials used in the studies reviewed in this paper, exact conclusions are quite difficult to make. Several treatment methods, namely the use of sandpaper[11] and plasma[15] were also only discussed in one article and thus no conclusions could be drawn regarding the effectiveness of these methods on the bond strength improvement between soft liners and acrylic resin. Finally, all studies reviewed are in vitro studies, most of which are cross-sectional studies. The results may not be fully applicable to real clinical situations. Perhaps, using more article databases could provide more articles to review and create more uniform data for further review.

It is concluded that surface treatment of the PMMA generally increase the bond strength between PMMA and soft liner when compared to the control group.

Several surface treatment methods, namely Er:YAG laser, MMA monomer, plasma argon, and combination of mechanical and chemical treatment show a higher bond strength between PMMA and soft liner than the control group. Meanwhile, methods such as Nd:YAG laser, KTP laser, and particles sandblasting show a lower bond strength compared to the control group. However, several factors such as the duration of the surface treatment, the laser energy intensity, and the sandblasting particle size may affect the end results.

On the other hand, acrylic soft liner and heat-polymerized liner show higher bond strength than silicone soft liner and auto-polymerized material, respectively. Also, specimens' immersion for one week shows the highest bond strength between two materials compared to the period of 24 hours and 1 month due to latent polymerization. However, further reviews are required in order to verify this latent polymerization effect.

Considering the limitations of this scoping review, it is suggested that further investigations are needed in regards to the efficacy of Nd:YAG laser, KTP laser, and sandblasting surface treatment in improving the bond strength between PMMA and soft liner from more databases so a uniform data may be collected.

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DOI: 10.46934/ijp.v4i2.243

Surface modifications of titanium based dental implant to accelerate osseointegration process

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ABSTRACT
Dental implants is a prosthesis that is invasively implanted in the patient's to replace missing teeth. Osseointegragration is the process where structural and functional relationships take place between bone and embedded dental implant surfaces. Unfortunately, titanium based dental implants show lack of osseointegration. Therefore, dental implant modifications could be one way to overcome this limitation. This article intensively reviews several surface modification methods to accelerate the osseointegration process on titanium dental implants. A literature review presented in this article. It is concluded that implant surface modification with other materials could accelerate the osseointegration process. Otherwise**,** modification of surface implants such as physical, chemical and biological mo-dification are discussed.
Keywords: implant surface modification, dental titanium, osseointegration

INTRODUCTION

Dental implants are one of denture abutments which are inserted into maxillary or mandible that interfaces with the alveolar bone for replacing missing teeth.[1,2] Dental implants are implanted to jaws in order to increase retention and support to the denture. Dental implant placement can restore the function of mastication, esthetic, and articulation.[1,3] Clinically, the success of dental implants can be seen in several indicators such as patient satisfaction, aesthetics, stability of dental implant, absence of soft tissue infection around the implants, retention of dental implants, and minimal bone loss radiographically.[3] Materials for dental implant can be divided into four groups: metal, ceramics, polymers, and hybrids.[4] Until now, widely used material for dental implants is titanium (Ti) because it has low density, high strength, non-toxic, and resistant to corrosion. Despite these advantages, one of the disadvantages of titanium is the lack of osseointegration between the implant and bone.[3]

Osseointegration is the structural and functional relationship between bone and dental implants surface.[5] This osseointegration is the key to the stability of dental implants and considered a pre-requisite for the success of a dental implant.[3,5] Osseointegration in dental implants is considered to develop if there is no progressive movement between dental implants and bone in direct contact.[6] The osseointegration process can be influenced by two factors, the bone-dental implant interface environment and the design of the dental implant itself. The material, surface, and topology of the implant can affect the osseointegration process.[4] Dental implants made of titanium produce poor osseointegration so that modifications of implant surface are required.[3]

Implant surface modification is a technique used on the surface of dental implants to increase surface roughness, physically mimic bone structure, and improve implant biocompatibility. Modification of dental implants surface plays an important role because that is one of important factors affecting the osseointegration process. Methods of implant surface modification can be divided into three categories; physical, chemical, and biological, which have their own advantages and limitations.[4] Based on this, the authors are interested to investigate more thoroughly about the various surface modifications to accelerate the osseointegration process in titanium dental implants.

LITERATURE REVIEW

Dental implants are prosthetic devices surgically implanted into the alveolar bone in either the maxilla or mandible to replace missing teeth. Dental implants can also be defined as substances placed in bone to provide retention and support for fixed or removable dental prostheses.[2,7]

The materials used for implants have undergone significant developments. Being able to withstand mastication loads, biocompatible, resistance to fracture, and non-corrosion are properties that must be possessed by an ideal implant material. Materials with mechanical properties similar to bone can increase the amount and rate of bone growth. Based on the nature of the materials used for fabrication, dental implants can be divided into three groups: metals, ceramics, and polymers.[4,8]

Metal has been used for many years and remains the most frequently used material in orthopedic surgery due to its biomechanical properties.[4]

DOI: 10.46934/ijp.v4i2.244

Titanium (Ti) is the most commonly used metal for implants worldwide and material of choice for implants because it has a good potential to fuse with bone. It has high durability, resistance to corrosion, and low modulus of elasticity. Ti6Al4V (Titanium; 6% aluminum; 4% vanadium) is titanium alloy with good mechanical properties compared to other titanium alloy. Aluminum in Ti6Al4V can increase the strength and density of metals while vanadium can prevent corrosion of aluminum. The disadvantage of titanium is it can cause allergic reactions. Allergy to titanium material can cause facial eczema, dermatitis, rash, and hyperplastic gingiva.[4,8]

Osseointegration is a structural and functional relationship between bone and implant surface without involving connective tissue. Osseointegration consists of two Latin words; *os*, which means bone and *integration*, which means to unite as a whole. The American Academy of Implant Dentistry (AAID) defines osseointegration as the strong, direct and lasting biological attachment of an implant to bone without the intervention of connective tissue.[7,9,10]

Osseointegration is a dynamic process involving a cascade of responses and the nature of the implant surface plays a major role in the success of the process. A cascade of cellular and extracellular biological events is involved in the healing of the bone around the implant. When the implant is inserted, an inflammatory response causes the release of several proteins such as cytokines and growth factors to form a blood clot. Proteins and lipids from the blood clot are then absorbed by the surface of the implant and then coat the surface of the implant. This pro-tein coat acts as a marker for cell proliferation and migration. Adhesion strength and protein type are influenced by properties of the implantsurface such as topographic features, surface roughness, and hydrophilicity. Blood platelets then form a fibrin matrix that acts as an intermediary or *bridge* for cell adhesion and migration.[4]

Macrophages and neutrophils will then adhere to the implant via the fibrin matrix 2-3 days after implant placement. Macrophages and neutrophils then remove pathogens and necrotic tissue and provide room for new blood vessels by breaking down the clot. Angiogenesis then occurs in the gap between implant and the bone four days after the implant placement. Mesenchymal stem cells (MSCs) will then gather around the blood vessels. Affected by cytokines and growth factors, MSCs differentiates and transforms into osteoblasts which can produce extracellular matrix and form immature woven bone. Implant surface and cell communication can direct MSCs to differentiate into fibroblasts which can stimulate the formation of a fibrobrous membrane on the surface of dental implants and interfere with the bone formation process.[4]

Woven bone formation will occur for 1-2 weeks after the implant is implanted and this phase is called the osteoconductive phase. Woven bone is a primitive type of bone tissue that is characterized by random collagen fibrils, low mineral density, and irregular shaped osteocytes.[4,10] There are two types of osteogenesis that occur based on where the MSCs is attached, distance osteogenesis and contact osteogenesis. Distance osteogenesis is the formation of bone that starts from the bone following migration to the implant surface through the fibrin matrix. Contact osteogenesis is bone formation initiated directly at the implant surface. These two processes of osteogenesis occur interactively, in which bone undergoing distance osteogenesis transmit signals to induce contact osteogeesis.[4] Distance and contact osteogenesis can provide secondary stability of implant (Fig.1).[4,10]

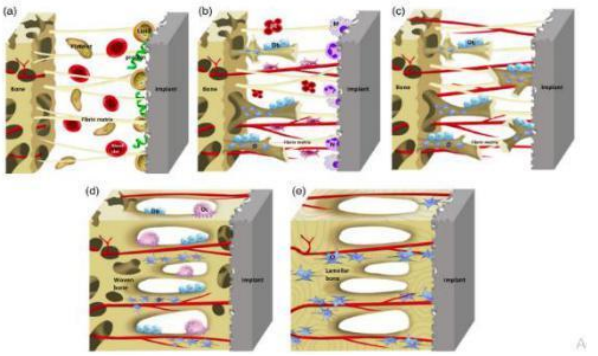

Figure 1 Osseointegration process in implants; **a** absorption of proteins and lipids from blood clots, **b** angiogenesis and woven bone formation, **c** distant osteogenesis and contact osteogenesis, **d** woven bone fills the gap between bone and implant and bone remodeling occurs, **e** woven bone turns into lamellar bone (Sources: Liu Y, Rath B, Tingart M, Eschweiler J. Role of implants surface modification in osseointegration).

The gap between the bone and the implant will then be filled with woven bone within two weeks and then the final process of osseointegration, i.e. apposition and bone remodeling, occurs. At this stage, the osteoclasts and osteoblasts work in harmony and the woven bone will gradually become parallel fiber bone and then turn into lamellar bone.[4] Parallel fiber bone is an intermediate stage between woven bone and lamellar bone while lamellar bone is the most complex type of bone with the highest strength.[10] At this stage the osteoclasts absorb the newly formed bone to overcome the microcrack and optimize the bone surface for lamellar bone formation. Osteoclasts form a sealing zone and create various microtopography and nanotopography containing biochemical information that

DOI: 10.46934/ijp.v4i2.244

will direct osteoblasts to areas that require new bone formation. This process then occurs continuously for a year or more.[4]

DISCUSSION

The nature of the implant surface has an important role in the osseointegration process therefore modifications of the implant surface are needed to improve the properties of the implant surface and assist the osseointegration process. Surface modification is a technique used on the surface of dental implants to increase the surface roughness of the implant, mimic the original bone structure, and improve implant biocompatibility[4] and accelerate the osseointegration process so that patient treatment time can be shortened. Modification of the implant surface produces changes in the morphology of the implant surface without affecting the physical properties of the implant material.[11] Surface modification can be divided into three methods, i.e. physical, chemical, and biological methods.[4]

Surface modification with physical methods

Surface modification with physical methods changes the topography and morphology of the implant surface using dry transformation technology to create a favorable environment for the osseointegration process. Surface modification using physical methods are grit blasting, plasma spraying, physical vapor deposition (PVD), and additive manufacturing (AM).[4]

Grit blasting is a surface modification method to increase the surface roughness of implants by firing abrasive particles at the implant surface.[2,4] There are several types of particles that can be used for grit blasting, they are titanium, calcium phosphate, and aluminium. Aluminium is the most commonly used particle. This is a simple method and does not cost much.[2,4]
The rough surface resulting from grit blasting will aid cell adhesion to the implant surface. Implant surface roughness is affected by size, shape, and properties of particles used. Aluminium particles in grit blasting can form an isotropic surface. Grit blasting can be combined with acid-etching to accelerate the process of osteogenesis. The disadvantage of this method is that the surface roughness formed can increase the adhesion of bacteria.[2,4]

The AM is a technology capable of making complex 3-D structures at the micro or nanometer scale. This method can form a layer-by-layer structure that is difficult to obtain through traditional processes. The layer-by-layer manufacturing process in AM can be carried out using lasers and electron beams.[4,10] The advantages of this method are that it can be used on all types of materials available in powder form, can produce complex shapes with details, and has high flexibility. This surface modification method can contribute to MSCs adhesion, alkaline phosphatase secretion, and collagen deposition.[4] This method can make implants based on computerized tomography (CT) of the patient thus produce suitable junction between implant and the bone contour of the patient.[13]

Plasma spraying is a thermal spraying technique in which the material is sprayed to coat the entire implant surface when the material is in a molten or semi-melted state. The material in powder form is put into the plasma and then melted at approximately 1000°C. The melted material spreads over the implant surface and subsequently solidifies and forms a deposit or lamellae layer.[4,14] An appropriate temperature is required for the material to reach a liquid state and not return to a solid state before reaching the implant surface. Temperatures that are too high can cause the material to evaporate before it reaches the implant surface.[14] This surface modification method is a safe and inexpensive method and the chemical composition present during the surface modification process does not persist on the implant surface. This surface modification method can improve biocompatibility, resistance to heat, corrosion, and damage, and osseointegration process.[4,14]

The PVD is a surface modification method that produces a vaporous material to cover the implant surface. This surface modification method converts the viscous material into a vapor then deposited on the implant surface in a viscous form. Sputtering deposition is the most commonly used technique for dental implants. Ion dispersion during the sputtering process removes substrate ions on the implant surface to create a space for the material for implant surface coating. The coating material will adhere firmly to the implant surface. This surface modification method can increase the resistance to corrosion and damage as well as increase the biocompatibility and hardness of the implant surface. Research shows that PVD can provide antibacterial properties and can increase angiogenenesis at the implant surface.[4,15]

Surface modification with chemical methods

The purpose of implant surface modification using chemical methods is to form a chemical junction between the implant surface coating material and bone. Chemical modifications can alter the implant surface through various chemical reactions

DOI: 10.46934/ijp.v4i2.244

such as carbonization, oxidation, or nitriding.[4]

Anodic oxidation (anodization) is an accelerated electrochemical process in which an oxide film is applied to the surface of the anode implant while the implant is immersed in a liquid electrolyte. This surface modification method is used to enhance anodization by accelerated electrochemical process in which an oxide film is applied to the surface of the anode implant while the implant is immersed in a liquid electrolyte. This surface modification method is used to improve the anti-corrosion properties of implants. Anodization can increase the bioactivity, osseointegration, surface roughness, and hydrophilicity of implants. Micro and submicro surface roughness formed by anodization can increase the adhesion of osteoblasts to the implant surface.[4,16]

Sol-gel is a low-temperature method that forms oxides or solids by heat treatment. In this method, organic or inorganic compounds undergo hydrolysis polymerization and turn into a colloidal solution (sol) which will then gradually turn into a two-phase system that resembles a gel. The implant furthermore dipped in the solution and removed at a predetermined time. The remaining liquid afterward removed through a drying process resulting in shrinkage of the structure. Heat treatment subsequently carried out to improve the mechanical properties and polycondensation. This method is fulfilled at low temperatures hence, the chemical composition of the coating material can be adjusjusted. When combined with other coating materials, sol-gel may form a bioactive layer that can respond to bone structure.[4,11]

Acid etch; this surface modification method uses a strong acid to change the surface of the implant. The acids used can be nitric acid (HNO_3), hydrofluoric acid (HF), and sulfuric acid (H_2SO_4).[17] The reduced surface of the implant in this method can be affected by the acid concentration, type of acid, etching time, and temperature.[2,17] Sulfuric acid is an acid that has been shown to be effective in increasing implant surface roughness.[17] Acid etching can remove the passivation layer and expose the underlying implant surface. Acid etching can produce a rough implant surface, increase the migration and retention of osteogenic cells, increase bone adhesion and formation, and promote osseointegration. This method can reduce the risk of contamination in the blasting method.[2,11,17] The disadvantage of this method is that chemical changes can occur on the surface of the implant treated with this method.[11]

Alkaline treatment is a surface modification method that involves immersing the implant in a high-alkaline solution and then heat treatment. Alkaline treatment can form nano holes and increase apatite nucleation on the implant surface.[10,18] This combined with acid etching can increase surface porosity and develop bioactivity without disturbing the shaft structure and mechanical properties of the implant material.[2,18]

Chemical vapor deposition (CVD) is a surface modification in which a gaseous compound undergoes a chemical reaction on a heated surface and furthermore creates a solid film on the implant surface. Just like PVD, deposition and condensation procedures of materials are also involved. The thing that distinguishes between PVD and CVD is the coating of deposits on the surface of the implant, CVD coats the surface of the implant through chemical bonds while PVD coats the surface of the implant using physical force. This method can enhance the potential for osseointegration and make homogeneous structure.[4]

Surface modification with biological methods

This method uses cell implants and biological coatings that can elevate the attachment, differentiation, and proliferation of osteoblasts. It is an additional method to improve osseointegration. Cells implanted onto the implant surface could be bone marrow-derived stem cells (BMSCs), mesenchymal adipose stem cells (AMSCs), mesenchymal stem cells (MSCs), and embryonic stem cells. The proteins implanted could be vascular endothelial growth factor (VEGF) and extracellular matrix protein (EMP). Implantation of cells may promote osteogenic adhesion, growth, and differentiation and advance bone formation. The disadvantage is cells and proteins embedded into the implant can penetrate the surrounding tissue or space, causing side effects and formation of fibrous membrane.[4]

Platelet rich plasma; biologically, plasma is the non-cellular part of the blood. The PRP is a platelet-rich blood plasma that can promote healing and early bone apposition. The application of PRP with zoledronic acid to the implant surface can provide good functional and aesthetic results. Studies have shown that implant surfaces modified using PRP with zoledronic acid can amplify the number of filopodia in osteoblasts attached to the implant surface, indicating the potential of PRP to improve early bone apposition and stability of dental implants, especially in patients undergoing bisphosphonate treatment.[19]

Extracellular matrix (ECM); during the osseointegration process, fibroblasts secrete ECM mole-

DOI: 10.46934/ijp.v4i2.244

cules such as collagen, vitronectin, and fibronectin that guide osteoprogenitor cells to surfaces that require new bone growth. ECM cell interactions can activate signals to promote bone healing. The implant surface coated with ECM molecules such as collagen sulfate or hyaluronan collagen might boost bone formation and maturation accordingly the application of ECM on the implant surface is considered to provide good results for the osseointegration process.[19]

Arginylglycylaspartic acid (RGD) is a specific amino acid which plays an important role in migration and adhesion of osteogenic cells. The RGD could initiate cell interactions resulting in cell attachment such as osteoblast adhesion.[19] Research has shown that RGD-coated implants might elevate bone-to-implant contact for three months post-implantation. However, there are studies showing that within two weeks post-implantation, there is no bone-to-implant contact and new bone filling on implant surface.[19]

The P15 peptide is an artificial amino acid which mimic cell-binding properties of human collagen. The application of P15 peptide on the implant surface can increase the attachment of osteoblasts and mesenchymal cells and increase the discharge and differentiation of osteogenic cells, accelerating the osseointegration process. When combined with competence-stimulating peptide (CSP), this peptide can have an impact on osteogenic activity and suppress biofilm formation.[19]

Strontium-incorporated protein can significantly improve bone-to-implant contact, bone formation, and mechanical properties of implants when applied to the implant surface. More specifically, this method may increase the initial adhesion, proliferation, and osteogenic differentiation of bone marrow stromal cells, increase the release of osteogenic genes such as bone morphogenetic protein 2 (BMP-2), and increase ability of new bone formation. There are several techniques to coat the implant surface with strontium-incorporated protein but it does not have a major effect on the contact between the bone and the implant surface.[19]

Growth factors; platelets and macrophages present in the early phase of osseointegration release several growth factors such as transforming growth factor β (TGFβ), and fibroblast growth factor (FGF) to facilitate the next phase of osseointegration. The application of these growth factors to the implant surface can accelerate the osseointegration process. Bone morphogenic proteins (BMP) such as BMP-2, BMP-4, and BMP-7 which are part of TGFβ for stimulating bone formation. When applied on the implant surface, BMP can enhance bone regeneration and provide better bone-to-implant contact and new bone formation.[19]

The FGF, especially FGF-2, can directly amplify the proliferation of osteoblasts. Cell dispersion and differentiation as well as osseointegration might enhance if FGF 2 nanoparticles are applied to the implant surface.[19]

It is concluded that titanium is the material of choice for dental implants because titanium has a good potential to integrate with bone. It is the most commonly used material because it has high durability, resistance to corrosion, and low modulus of elasticity. Ti6Al4V alloy is titanium with good mechanical properties compared to other titanium alloy.

Properties of the implant surface have an important role in the osseointegration process hence, modifications to the implant surface required to improve the properties of the implant surface and assist the osseointegration process. Surface modification is a technique used on the surface of dental implants to increase the surface roughness of the implant, mimic the original bone structure, and improve implant biocompatibility.

Surface modification can be divided into three methods, i.e. physical, chemical, and biological methods. Physical methods include grit blasting, plasma spraying, PVD, and AM. Chemical methods include anodization, sol-gel, acid etching, alkali application and CVD. Surface modification with biological method use cell implants and biological coatings which might increase the attachment, differentiation, and proliferation of osteoblasts.

The main disadvantage of the current implant surface treatment is the lack of clinical data which necessitates more clinical and laboratory studies. The future of dental implants will depend on more efficient, sophisticated and well-designed standardized clinical and laboratory research methodologies for developing and attaining implant surface treatment standards.

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DOI: 10.46934/ijp.v4i2.244

Hardness testing of five brands of acrylic artificial teeth

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ABSTRACT
Acrylic artificial teeth are still widely used in denture fabrication. Several brands marketed in Bandung claimed that their product has met the standard but all the brands do not give the mechanical properties data including hardness. The ADA specification standard no. 15 requires a hardness of minimum 15.00 KHN for acrylic artificial teeth. This study is aimed to find out which acrylic artificial teeth have a standardized hardness value. The study is an analytic descriptive study performed on five brands of acrylic artificial teeth marketed in Bandung. The samples were given 10 indentation spots on the upper and lower surfaces. The results of the study were analysed using Anova test and Dunnet test. The analysis showed that the hardness value of the upper and lower surfaces was as followed, respectively: A, 17.95 KHN and 17.46 KHN; B, 17.01 KHN and 17.49 KHN; C, 18.24 KHN and 17.41 KHN; D 17.61 KHN and 17.01 KHN; E 17.01 KHN and 16.59 KHN. The two-ways Anova showed that the hardness value of both surfaces does not differ significantly. It was concluded that the five brands have met ADA specification standard no. 15 and there were differences in hardness values among the brands.
Keywords: acrylic artificial teeth, ADA specification standard no.15, hardness

INTODUCTION

In dentistry, since 1930 until now acrylic artificial teeth are still widely used, especially in the manufacture of removable dentures. Some of the advantages of acrylic artificial teeth are light weight, easy to grind and polish, self-adjusting and self-balancing. While the disadvantages are that it is less strong and has low abrasion resistance so that it can change occlusion and vertical dimension.[1-4]

Acrylic artificial teeth (AAT) on the market must meet standards, one of which must comply with the American Dental Association (ADA) standard specification no.15. The AAT that meet this standard are made of polyacrylic, polyacrylic fillers, polyvinyl ester copolymers or mixtures of these plastics. In addition, chemical bond between the AAT and the base (bond strength) is 315 kg/cm2 (31 MPa), hardness is not less than 15.00 kg/mm2 (KHN), does not change color or shape when heated in hot water at 100°C for 3 hours.[4,5]

Hardness is one of the important properties in dentistry, so the hardness test is included in the requirements for obtaining specifications from the ADA.[6] Hardness is the resistance of a material to indentation or penetration on a permanent surface. Hardness gives an idea of the possible abrasion of the denture material. The surface properties of acrylic resin can be affected by hardness, which is a characteristic of the material's ease of finishing because it is resistant to scratches during cleaning.[7-9]

Some commercial brands marketed in Bandung claimed that their product has met the standar but all the brands do not give the mechanical properties data including hardness. In addition, dentists also often find patients with acrylic artificial teeth whose wear and tear on the surface of the artificial teeth have even been accompanied by a decrease in vertical dimensions.

METHOD

This research is descriptive analytic research. The samples of this study were five brands of AAT circulating at the dental depot in Bandung, each brand taken 4 dentures as samples. The sample was ground flat with a thickness of 2.5 ± 0.5 mm and buried in clear resin, this is in accordance with the ADA standard AAT hardness test.[5,10]

Samples were tested using the Knoop hardness tester. The results of the Knoop indenter shape a diamond pyramid with a diagonal of 280.8-

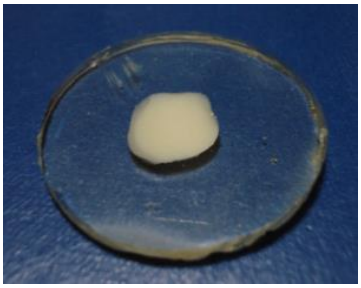

Figure 1 Sample

Table 1 Mean hardness of AAT on upper surface (KHN)

Sample	Acrylic Artificial Teeth Brand				
	A	B	C	D	E
I	16.80	16.57	19.05	17.58	18.00
II	17.48	17.12	18.44	17.53	17.10
III	17.82	17.52	17.87	17.48	16.96
IV	19.71	16.81	17.58	17.86	15.92

DOI: 10.46934/ijp.v4i2.245

Table 2 One-way anova for the hardness value of AAT on the upper surface

Source of variations	Degree of freedom	Sum of square	Mean square	Fvalue	$F_{0.05}$	
Between group	5	26.80	5.36	11.10	2.77	Sign
Within group	18	8.70	0.48			
Total	23	35.50				

311.1 m. The smaller the diagonal, the greater the hardness value and the larger the diagonal, the smaller the hardness value. Each sample was stressed 10 times using a load of 100 g for 20 seconds. Pressure is placed on the top and bottom surfaces. The results of each surface test are calculated on average, so that one hardness value is obtained from one AAT.

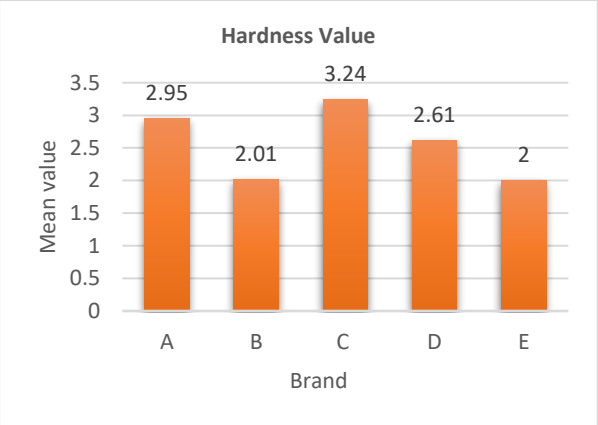

Diagram 1 Mean difference in the hardness values of the upper surface AAT in five brands with the standard values

Table 3 Dunnett test comparison of hardness values of upper surface AAT on five brands

(I) Brand	(J) Acrylic artificial teeth Standard	Mean difference (I-J)	Sig.	
A	Standard	2.95	0.00	Sign
B	Standard	2.01	0.00	Sign
C	Standard	3.24	0.00	Sign
D	Standard	2.61	0.00	Sign
E	Standard	2.00	0.00	Sign

RESULT

The results of the study will be analyzed using one-way Anova F test statistics to see if there is a difference in the average hardness value of AAT on various brands of AAT against the ADA standard specification no.15. If there are differences, further analysis will be carried out using Dunnett's test. Furthermore, to see the difference in hardness values between the upper and lower surfaces of five AAT brands, a two-way analysis of variance was performed.

DISCUSSION

Based on table 2, it is known that the calculated F 11.10 is greater than F0.05;5;18 2.77, this means that there is a significant difference in mean AAT hardness value on the upper surface between the five brands of AAT with a value of standard. To see which brand of AAT has a different surface hardness value from the ADA standard no.15, it was followed by Dunnett's test after analysis of variance.

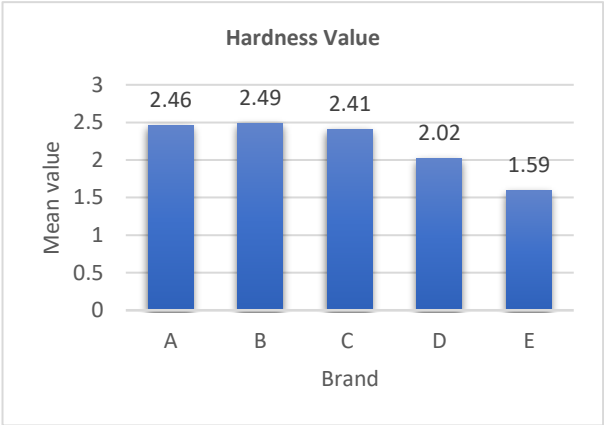

Diagram 2 Mean difference in the hardness values of the lower surface AAT in five brands with the standard values

Table 4 Mean hardness of AAT on the bottom surface (KHN)

Sample	Acrylic Artificial Teeth Brand				
	A	B	C	D	E
I	17.36	18.04	16.34	16.79	16.61
II	17.61	16.86	16.97	17.48	17.04
III	17.62	17.34	17.48	16.33	17.08
IV	17.25	17.72	18.83	17.48	15.63

From table 3, Dunnett's test compares the hardness values of the upper surface acrylic artificial teeth on brands A, B, C, D, and E to the ADA standard. Mean hardness value of the lowest upper surface acrylic artificial teeth is brand E with an average difference of 2.00 compared to the standard, while the highest is brand C with an average difference of 3.24 compared to the standard.

Table 5, it is known that F count 10.12 is greater than F0.05; 5; 18 2.77, this means that there is a significant difference in the value of artificial teeth hardness on the lower surface between the five brands of dentures with standard.

Table 6 Dunnett test comparison of the hardness values of undersurface acrylic artificial teeth on brands A, B, C, D, and E against the standard, the result is that the hardness values for AAT on the five brands have a higher mean hardness value compared to the ADA standard. The lowest mean hardness value for AAT undersurface is the brand with a mean difference of 1.59 compared to the

DOI: 10.46934/ijp.v4i2.245

Table 5 One-way Anova for hardness value of acrylic denture on bottom surface

Source of variations	Degree of freedom	Sum of square	Mean square	Fvalue	$F_{0,05}$	
Between group	5	18.42	3.68	10.12	2.77	Sign
Within group	18	6.55	0.36			
Total	23	24.98				

Table 6 Dunnett test comparison of hardness values of lower surface AAT on five brands

(I) Brand	(J) Acrylic artificial teeth Standard	Mean difference (I-J)	Sig.	
A	Standard	2.46	0.00	Sign
B	Standard	2.49	0.00	Sign
C	Standard	2.41	0.00	Sign
D	Standard	2.02	0.00	Sign
E	Standard	1.59	0.00	Sign

Table 7 Two-way Anova hardness value in AAT

Source	Degree of freedom	Sum of square	Mean square	Fvalue	F Table	
Mean	1	12077,71	12077,71			
Factor A (Surface)	1	1,35	1,35	2,65	4,17	Non-Sign
Factor B (Brand)	4	5,33	1,33	2,62	2,69	Non-Sign
Interaction AB	4	2,02	0,50	0,99	2,69	Non-Sign
Error	30	15,25	0,51			
Total	40	12101,66				

standard, while the highest is brand B with a mean difference of 2.49 compared to the standard.

Table 7 shows that the upper and lower surfaces of each brand of acrylic artificial teeth gave results that were not significantly different from mean hardness value of AAT.

These five brands of AAT have complied with the ADA standard specification no.15, namely values above 15.00 KHN. According to Craig[4] the hardness value of AAT is about 18-20 kg/mm2, in this case, only brand C is met.

One of the most important physical properties of artificial teeth used is hardness. The hardness of AAT plays a crucial impact on comfort and superior quality of mastication by aiding in the maintenance of stable occlusal relationship over time. Failure to maintain the same causes loss of masticatory efficiency, faulty tooth relationship and increased horizontal stresses and their associated sequelae. The mechanism of wear in occlusal contact areas of dental restorations is not completely understood. Three basic types of wear have been suggested: frictional wear or the interaction of microscopic irregularities, adhesive wear produced during the shearing of surface irregularities between the two occluding surfaces, and abrasive wear that occurs whenever hard foreign particles are present between the two occluding surfaces.[1] Wear depends on many factors such as neuromuscular forces and movements, lubricants associated with salivary flow and pH, foreign objects, exposure to an abrasive or corrosive atmosphere, patient's habit, diet, poor or excessive hygiene, and the type of restorative material used.[3,8]

One of the disadvantages of AAT is wear and tear, because the hardness value of acrylic is quite low compared to enamel and porcelain dentures. The AAT have been modified to overcome the disadvantage of wear by using cross-linking agents, different monomers, and the addition of fillers.[4,8]

New types of AAT using modified acrylic resin that incorporate cross-linking agents and composite resin containing filler have become increasingly common. A profoundly crosslinked system has the following advantages: color stability, plaque resistance, wear resistance, tissue compatibility, high grinding strength and excellent polishing properties (due to increased thermal resistance). Cross-linking agents also improve strength and crazing resistance. Double cross-linking procedure, eliminates the weak points of conventional polymethacrylate teeth, such as the exposure of uncross-linked polymer beads that detach during grinding. Simultaneously, the double cross-linking process leads to a considerably enhanced resistance to the mechanical wear caused by food, contact with the opposing dentition as well as tooth brushing.[8]

However, cross-linked AAT have been reported to demonstrate lower bond strength to denture base resin when compared to conventional AAT. Therefore, the ridge lap portion of the teeth is expected to be the least cross-linked so as to facilitate bonding to the denture base resin.[8,11,12]

It is concluded that all brands meet the ADA standard specification no.15. There are differences in the hardness values of the five brands of AAT. It is suggested that It is necessary to conduct further research on various factors that can

DOI: 10.46934/ijp.v4i2.245

affect the hardness of AAT as well as testing on other brands of AAT. There is a need for a testing agency tasked with testing the quality of dental materials in Indonesia.

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DOI: 10.46934/ijp.v4i2.245

Telescopic denture load distribution based on the telescopic crown design and material

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ABSTRACT
Retentive force (RF) on the telescopic crown (TC) retainer will be distributed to the abutment teeth. The optimal load distribution measured by RF on the abutment is 5-9 N. If the force is applied excessively, it will damage the tooth's supporting tissue, causing periapical lesions, bone resorption, and mobility. However, if the RF is minimal, the denture will not retentive. This paper will go through how RF will vary based on the chosen design and material. The cylindrical, conical, and resilient TC design are affected by the taper angle and the distance between the primary crown (PC) and secondary crown (SC). Resilience design can be modified by Marburg, Hofmann, and Yalisove. To create the precise taper angle and space in telescopic dentures (TD), CAD/CAM can now be used for the manufacture of TD using metal and non-metal materials. It is concluded that cylindrical TC design is rarely used because it is difficult to get tight contact between PC and SC, therefore conus or resilience design is more recommended. The smaller the taper angle, the greater the RF, but this depends on the material used. While the space between PC and SC, which is less than 50 µm, can also affect RF.
Keywords: telescopic denture, load distribution, telescopic crown design, telescopic crown material

INTRODUCTION

Treatment in edentulous patients varies in part depending on the patient's local and systemic factors. Local considerations include the quantity and position of missing teeth, occlusal relationships, the periodontal health of the remaining teeth, and the size or motion of the tongue.[1,2] The periodontal support of the support teeth and the design of the removable denture are two of the crucial elements in the planning of removable denture designs that are related to the distribution of loads to dental and mucosal supports. Once the denture is removed, a resultant force is applied to the supporting teeth along the lateral and vertical axes, and the periodontal support of the tooth must be strong enough to withstand this force.[1]

Removable denture design is one of the important factors in increasing long-term success and patient acceptance. The possibility of local soft tissue irritation or patient complaints can be caused by *unphysiologic* components in the form of major and minor connectors, functional extended border, and parts of the tissue teeth that cover the gingival margins of the support teeth.[3]

The ultimate tensile strength, which ranges 0.33-6.82 MPa, is the amount of force necessary to remove teeth from the socket.[4,5] According to Stantic et al, the force applied to each support tooth should be 5-9 N. Excessive force might harm the tooth's supporting tissue, leading to periapical lesions, bone resorption, and movement. However, removing prosthesis become easy if the RF is small.[5,6]

Retentive force on PC and SC when removing dentures will increase tensile stress on the support teeth. Strains that concentrate on the periodontal ligament and the apical region of the pulp tissue will cause periapical lesions. Meanwhile, if the strain concentrates on the bone and tensile stress on the periodontal tissue, it will cause resorption in the cervical area and increase the shaking of the support teeth.[5]

The TC outperformed other direct retainers in terms of effectiveness. This type of retention can be planned to adapt to the situation of the support gear by modifying the design of the telescope. The number of friction surfaces depends on the configuration of the taper angle and the space between PC and SC.[7] The design of a TC is generally classified into three types based on the retention mechanism: cylindrical, conus/conical, and resilient/clearance fit. Resilient design can be modified into Marburg design, Hofmann and Ludwig design, and Yalisove design. To get an accurate taper angle and space on the TD, CAD/CAM can be used with metal (CoCr) and nonmetal (Zirconia, PEEK).

This paper aims to discuss how RF will differ based on the design and material of the TC used. The design of the telescopic crown in the forms of cylindrical, conus, and resilient is influenced by the taper angle and space between the PC and SC. Various designs will result in different RF, so the dentist must be aware of this and modify the TC's design in accordance with the state of the supporting teeth.

DOI: 10.46934/ijp.v4i2.160

LITERATURE REVIEW

Telescopic denture/double crown system

A telescopic denture (TD) consists of a primary crown (PC) that is cemented into the support teeth and a precisely fitted secondary crown (SC). The PC must be at least 4 mm. Telescopic dentures, except clearance fit design, provide all the necessary functions of retentive elements such as retention, guidance, support and protection from movement. The double crown system distributes the load along the tooth axis so as to maintain the integrity of the periodontal ligament tissue and protect the tooth from dislodging movement of the removable denture. If the load is too great, it may result in issues such as periodontal damage, mucosal irritation, and patient pain.[1,2,8] Telescopic retainers offer treatments that can enhance natural maintenance and provide additional options for rehabilitating complex cases.[9]

The telescopic RPD was chosen because it produces support for teeth and soft tissues, has good retentive and superstructural qualities, a rigid splinting action, distributes loads effectively, and PC stabilizes dentures with mucosal support.[9] The advantages of the TD technique are excellent 3-dimensional immobilization of the restoration, defined release force, flexibility of design, and optimal access for oral hygiene. A PC with good adaptation can protect the support teeth from thermal irritation. In comparison to conventional RPD with clasp, the use of TD as a retentive element produces a better appearance, and TD can be repaired even if the supporting tooth is lost. [3,10]

The disadvantages of TD include a complex clinical and laboratory approach, which demands more treatment time and raises expenses. It is also difficult and challenging to achieve the ideal retention between PC and SC. Due to wear between the crown materials after TD use, the RF between the crowns may decrease. In order to provide space for PC and SC during the restoration of the support teeth, a significant amount of tooth material must be removed, which increases the risk of dental pulp morbidity, particularly in young patients. In TD, follow-up, regular review, and maintenance are required.[3,10]

The use of a telescopic denture is indicated when there are few and unevenly spaced support teeth, when those teeth need to be covered with a crown due to significant caries and poor contours, when those teeth have a questionable prognosis, when periodontitis has advanced, when it is challenging to determine the direction of the tide in the case of non-parallel support teeth, when someone has oral cancer, when natural teeth need to be connected to implants, when performing occlusal reconstruction and in patients with poor manual dexterity.[11]

According to the retention mechanism, the three types of telescopic crown designs are generally cylindrical, conus/conical, and resilient/clearance fit (Fig.1).

Figure 1 Design of TC; **a** cylindrical, **b** conical, **c** resilient

Cylindrical telescopic crown

The cylindrical crown's parallel surface (0°) produces a piston-cylinder effect that aids in gaining retention through frictional forces.[1] A cylindrical crown can only be used on teeth with good support tissue where it requires large retention. However, nowadays it is rarely used because retention is obtained from tight contact, so it is now more advisable to design a conus crown.[5,11]

The benefits of a cylindrical crown are its ability to alter retention force, good and stable RF over time, the ability to support teeth by acting as a splint, the ability to preserve periodontal tissue, and good removable denture retention. However, the limitations include the possibility of visible metal on the cervix, large RF on the support teeth when the GT is removed, the need for spacious vertical and buccal spaces, the potential need for endodontic treatment, easy insertion, and the need for a precise and accurate fit between the PC and SC during manufacturing. [1,11]

Conical or conus telescopic crown

It was first described by Korber in 1958 and provided friction only when completely seated produced a *wedging effect* that created a large resistance force surface and increased RF.[1,6] A good tapered conus crown design can facilitate the installation and removal time of the TC without providing excessive friction that can affect the supporting tissue of the tooth. The smaller the taper angle conus crown, the larger the RF will be. The incline of the PC depends on the height of the clinical crown and the mobility of the periodontal. The number and location of the support teeth are also factors influencing the design of the taper and the total RF is calculated based on the number.[1,6,9,11]

Conus crowns are more commonly used over cylindrical crowns because they are easier to fa-

DOI: 10.46934/ijp.v4i2.160

bricate and do not significantly damage the tissues supporting the support teeth, but retention will decrease over time.[11] Because of its rigidity, the conus crown removable denture is not recommended for teeth with periodontal disease or questionable soft tissue conditions. When the removable denture retention is lost due to conus crown wear, polishing the occlusal surface of the PC with a silicone polishing disc can enhance the wedging effect so as to increase RF.[1]

The conus crown has the advantage, which is that it can adjust the RF to the condition of the support teeth. The retention force is stable over a long period of time, provides the effect of splinting the support teeth, maintains the periodontal tissue well and is aesthetically pleasing. However, the disadvantage is that sometimes there is an overconture appearance, the possibility of visible metal on the cervix, requiring root canal treatment if needed, when the support tooth is removed, the retention of the removable denture is doubtful, and it is a rigid connection.[1,11]

Resilience or clearance fit telescopic crown

Due to the flexibility in vertical and rotational movements, this type of design is referred to as a non-rigid design.[11] There is no friction or wedging when inserting or removing the removable denture. Retention is obtained from modifying the PC and SC or by adding attachments or functional molded denture borders and in contrast to other telescope systems, they can be used to maintain the removable denture with dental and/or mucosal support. This modification will reduce the tight contact between the PC and the SC and create a space between the PC and the SC.[1,2,11,12] In order to achieve optimum soft tissue support, the space between PC and SC allows for deformation and denture displacement toward the mucosa due to occlusal functional load.[1,13] This design also allows for the presence of resilience between the dentures and the support teeth, which can prevent harmful effects, harmonize with tissue elasticity, result in better distribution forces, and increase the survival rates of abutments. Resilience design provides advantages in cases with few or weak support teeth, and in situations of distal extention and in implant-supported dentures.[11]

Resilient design can be modified based on the angle and space between the PC and SC (Fig.2), which is a) Marburg Design. It is known as a resilient design and was first introduced by Lehmann and Gente in 1988. A third of the PC cervix is parallel to the SC and creates space between the crowns (Fig.2a). This space will allow for the occurrence of lateral minor movements of the crown and a smooth, effortless gliding along the axis of the insertion direction. This design offers guidance, support, and stability against dislodging motion but without retention. The marginal part of the periodontium supporting tooth is not covered by the denture base. [3,11] The Marburg design can be easily modified to obtain vertical movement, which when intended for mucosa-supported RPD should be able to accommodate 0.3-0.5 mm of vertical movement. The telescopic denture base will be in contact with the mucosal denture-bearing at the time of insertion, and there will be space between the PC and SC. When the occlusal is loaded, the denture will move vertically; the amount of movement depends on the compressibility (resilient) of the mucosal denture-bearing;[3] b) Hofmann and Ludwig Design. The half-cervical part of the PC is parallel to the SC and the half-occlusal part is conical with the presence of a space of 0.2-0.5 mm between the PC and the SC in the occlusal part (Fig.2b);[11] c) Yalisove design has a space in the cervix where only two-thirds of the occlusal is in contact. On the third of the servix, there is a 0.003-0.010 inch space between the PC and SC (Fig.2c), allowing the SC to rotate when the distal-end mucosa is under load and preventing unwanted friction. There is a difference between the self-supporting telescopic type with dental support using coping with tapers 2-3 and the self-releasing type with mucosal support using taper 16, where there is no retention, but there is support and load distribution along the axis of the support teeth. [9,11]

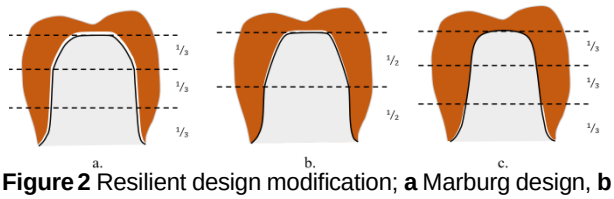

Figure 2 Resilient design modification; **a** Marburg design, **b** Hofmann and Ludwig design, **c** Yalisove design

Manufacture of primary and secondary crowns

The conventional manufacturing process, also referred to as the lost-wax technique in the manufacture of PC and SC, has shortcomings due to the high casting temperature and oxidation properties of the metal after casting. The high modulus of elasticity of the material makes manual processing and RF adjustment more difficult In the micrometer range, zero tolerance of an undesired press or clearance fit is obtained. [14]

Recently, CAD/CAM systems have attracted great attention as a suitable alternative to the wax loss technique in the manufacturing of metal. Over

DOI: 10.46934/ijp.v4i2.160

time, the processing accuracy of CAD/CAM systems has improved greatly thanks to the improvement and development of measuring devices and processing machines. One of the main benefits is that digital technology has the characteristic of producing very precise results up to within the range of the micrometer when the parameters used are correct and can avoid errors related to conventional systems.[13,14] With the development of CAD/CAM technology, new methods in the manufacture of metals and non-metals can be carried out starting from the wax-up process to obtain precise and accurate results. The internal and marginal fit of the milled crown, which might take the shape of an angle taper and the space between the PC and SC, is either superior or equal to that of the cast crown.[15-18]

Primary and secondary crown materials

In dentistry, especially in prosthetic dentistry, metal alloys are the most common material due to their excellent physico-mechanical properties, with precious and non-precious metals. Precious metal is the first choice in making TC, but due to economic reasons, non-precious metal has also been used.[1,15–18] The material originally used for the manufacture of PC and SC is high-gold alloy due to the relatively low modulus of elasticity compared to other metals that allow conventional manufacturing through casting technology and uncomplicated adjustments chairside. Since the price of gold has increased significantly over the past few decades, numerous other materials can be employed with various TC designs. [14]

The TC and metal-free dental prosthetics have both become popular in recent years. The use of ceramic materials in the manufacture of telescopic dentures began in 2000 and has a high demand not only among dentists but also among patients. Zirconia and PEEK materials are biocompatible materials with good mechanical properties and excellent aesthetics.[1,15–18]

PEEK is a polymeric material with high thermomoplastic polymer density properties with a semicrystalline aromatic linear structure that has good physical and chemical properties such as toughness, hardness and elasticity, and a low molecular weight in the absence of metal that provides biocompatible denture material. [17]

Zirconia, also known as ZrO2, is a ceramic materterial with high biocompatibility that exhibits outstanding bending and tensile strength, extremely high compact resistance, and self-repairing capabilities that stop fracture propagation. There are various forms of zirconia used in dentistry, including Yttria full stabilized tetragonal zirconia polycrystal, zirconia toughened alumina, and magnesium partially stabilized zirconia (Mg-PSZ) (3Y-TZP).[15,17]

DISCUSSION

Telescopic dentures with cilindrical and conical crown designs provide a rigid support on the support teeth. If the load given is large and only on a few support tooth, it can cause teeth mobility and premature tooth loss.[3] According to Sahin et al., a rigid-design telescopic denture produces a larger strain on the support teeth than a resilient one.[2] Therefore, it can be said that cilindrical, conical, and resilient crown designs can be used on RPDs supported by the tooth- or tooth-mucosa-support, but only resilient crown designs can be used on RPDs supported by the mucosa support since only these designs can offer the PC and SC with vertical movement. This is due to the fact that the cilindrical and conical crown designs, which induce friction and wedging effects, are unable to tolerate RPD movement in either the occlusogingival direction under load or the opposite way when the load is removed.[3]

A number of variables, including PC thickness, PC height, taper angle, SC adaptability, and space width in the occlusal section of the PC and SC, might affect the retentive force in the telescopic crown.[13] Retentive force in the TC occurs in the entire removal process where the conical crown can be removed forcelessly shortly after the initial force. Different types of retention will have an impact on how the TC surface wears when in contact. Friction and keying will result in wear due to abrasion, adhesion, and consecutive surface spalling.[8] When the load given is large, the SC goes deeper due to the increase in strain and RF.[6]

The retentive force on the conical crown has a significant effect when the taper angle and the height of the support teeth are modified due to the wedging effect where the taper angle on the PC provides a wider resistance surface. In order to increase the RF, the wedge effect deepens and the taper angle decreases. As a result, the taper angle may affect RF management. Therefore, the taper angle can be a factor controlling the RF. Clinically, RF ranges 5-9 N per supported tooth. The RF difference that occurs due to the taper angle can be related to the coefficient of static friction of the material. The smaller the taper angle, the smaller the static friction coefficient. When the SC sits on the PC and the load is applied to the occlusal surface, the side surface of the SC will undergo a slight deformation due to the wedge effect that will produce RF.[6,8,13,19] Gungur et al reported that RF TC in-

DOI: 10.46934/ijp.v4i2.160

creased as the taper reduced. This is also the same as Nakagawa's research, which stated that there was a significant difference between RF and PC angle tapers when given different forces regardless of the space between the PC and the SC.[19]

It is crucial to note that the conical crown's retention mechanism varies from that of the cylindrical crown. Deformation from the SC is therefore prevented if there isn't space on the occlusal surface between the PC and the SC, which means that the RF won't happen. Therefore, the angle and space taper between the PC and SC can be used as one of the factors in regulating RF.[6,8,13] In the absence of space, the PC and SC will have tight contact and when the load is given, there can be no deformity in the SC and this can damage the RF, which can be said to be sheared or sliding between the PC and SC. Shimakura et al. tested specimens with 0, 50, and 100 µm occlusal space and found that there were significant RF differences in spaces of 0 and 50 µm, but there were no significant RF differences in spaces of 50 and 100 µm.[13] Schwindling found the resulting RF in accordance with the force required in the abutment teeth when there was an occlusal space of 50 µm. However, in another study that looked at the space of 0, 10 and 20 µm between PC and SC, there were no significant RF differences.[6,19] Nakagawa also stated that the space setting does not show a significant difference, but if there is no space on the occlusal surface on PC and SC during insertion, there will be no RF due to the wedge effect. The increase in load will increase RF but is not affected by the space.[19]

Shimakura looked at RF at telescopic dentures with heights of 4 and 6 mm; taper angle of 6; space between 0.50 and 100 µm; knife edge margin. The results of his research showed that TC with a height of 4 mm; space 0 µm; load of 50 N, found RF of 6.3 N. Along with the addition of space in the occlusal region and the increased load, the RF is also increasing. When the height is 4 mm with a space of 100 µm, the maximum RF reaches 17.4 N. At a height of 6 mm with a space of 0 µm, a RF of 7.8 N is found; and in a space of 100 µm a maximum RF of 35.6 N is found.[13]

A large load, a small angle taper, a thin SC, and a wide shoulder on the PC cervix will result in a large RF. This is evidenced in the research of Nakagawa et al which states that the taper angle on the conus crown shows the greatest contribution (74.5%) followed by the load received (11.62%); errors in load, PC space and SC, SC thickness and shape of the PC cervical border.[6]

One of the most frequent technical failures is retention loss, which depends on the principle of a retention mechanism.[1] According to Arnold et al, the combination of materials and manufacturing techques used affects the RF on TC. The properties of the material used to create the double crown are crucial.[1,14] In the CAD/CAM manufacturing process, milled non-precious metal TC showed the highest RF and also during wear simulation. This is because the results of CAD/CAM have a uniform surface, not too rough, with a consistent distance between PC and SC. In the conventional manufacturing process, a lower RF value was found with a significant RF loss. This is due to the fact that the TC surface is inhomogeneous with a thickness that varies between PC and SC and has irregular surface contacts. The retention or friction of the results of the fabarication of the TC conventional is ensured through recurring elevation and punctual contacts.[14] When making TC by the lost-wax method, the technician needs to pay attention to the water-powder ratio of the investment material and control the expansion of the casting mold to obtain the appropriate space between the PC and SC. Therefore, it requires the ability, experience, and accuracy of dental laboratory technicians in making TC. [8,13]

Research according to Wagner et al, telescopic denture with PEEK material made with CAD/CAM system shows stable retention load value and according to Joao Paolo et al also stated that PEEK provides low-stress concentration due to low elastic modulus properties and good strength.[20] The higher the elastic modulus of the PC material, the higher the stress magnitude in the structure, but analysis of the periodontal ligaments and bones of the model showed that the PC material did not affect strain outcomes. [20]

When using non-precious metal materials that have a smaller modulus of flexibility, it can cause strains to increase and provide a hazardous effect. Where strains are effective in the distribution of loads on bone, pulp, periodontal ligaments and metal structures. Strain and tensile stress will also increase as the height and angle of the telescopic crown increase.[5] Arnold concluded that TC with different designs and different materials will produce different RF and long-term retentive behaviors as well. This is because the telescopic crown that has a lot of surface contact between the PC and SC can cause RF to be easily lost.[14]

Stock et al looks at RF on different PEEK materials with different tapers. Milled PEEK with taper 0 shows the lowest RF, whereas taper 2 shows the highest RF. Pressed PEEK does not show a sig-

DOI: 10.46934/ijp.v4i2.160

nificant RF difference with different angles. This is because pressed PEEK is softer so that it is easier to deform in SC so as to reduce RF. Ohkawa et al suggest that the maximum taper is 2 because if it exceeds 2, the retention will disappear quickly.[21] This is in line with the research of Merk who tested RF with zirconia as PC and PEEK (breCom BioHPP blanks milled, BioHPP pellet pressed, and BioHPP granulate pressed) as SC with angles of 0, 1 and 2. It was concluded that the highest RF was at an angle of 0 in the pressed pellet material group (21.4 N). At an angle of 1 milled PEEK had the lowest RF (6.8N), but at angle 2 there was no significant effect.[16] Although angle 1 with PEEK milled material has the lowest retention, the RF value is in the ideal RF range.

Nakagawa tested RF with Ce-TZP/A zirconia material with CAD/CAM as PC and SC with angles of 2, 4 and 6; and spaces of 0 and 100 µm. The average RF at angle 2 is 23 N, angle 4 is 8 N and there is no RF at angle 0. Good RF shows up on taper 4 with a load of 50 N.[19] Although at angle 2 it is the best RF, it has passed the ideal RF value, so it is feared that it will affect the periodontal health of the support teeth. This is in contrast to Nakagawa's research comparing the bright-stabilized material zirconia/alumina nanocomposite with CAD/CAM system, which found RF at angles 2, 4 and 6 is 35.8 N, 15.9 N and 1.4 N.[6] Where at angles 2 and 4 it has exceeded the recommended RF but angle 6 is below the optimal value of RF.[6]

It is concluded that telescopic crowns are classified based on the taper angle and space between the PC and SC into cylindrical, conical, and resilient designs. Cylindrical crowns and conus crowns are rigid designs, where cylindrical crowns have a parallel surface (0°) so as to get retention through frictional forces, while conus crowns get retention through wedging effect and have angles that vary 2-6 without any space between PC and SC. A resilient crown is also referred to as a non-rigid design, where there is no retention through frictional force or wedging effect and has a taper angle similar to the conus crown but has a space between the PC and SC which ranges 0-100 µm. This space allows the movement of the denture to the mucosa caused by the occlusal functional load so that it can compensate for the difference in mucosal compresibility.

Cylindrical TC designs are rarely used because it is difficult to get precise contact between the PC and SC, thus conus designs or resilient modifications are more recommended. Resilient crowns were modified into Marburg design, Hofmann and Ludwig design, and Yalisove design. This design is a modification of the combination of conus crown and/or cylindrical crown with the presence of space on several parts or the entire surface of PC and SC. The smaller the taper angle, the larger the RF, but this depends on the material used. While the space between PC and SC, which is less than 50 µm can affect RF, but without space on the occlusal surface between PC and SC, RF on a PC that has a taper angle will not occur. Therefore, the angle and space taper between the PC and SC can be used as one of the factors in regulating RF. This needs to be considered because the condition of the support teeth is not the same in every TD case, so that the RF produced on the support teeth can affect the periodontal health of the teeth.

It is suggested further research on the load distribution of telescope dentures based on resilient modified designs (Marburg, Hofmann, and Yalisove designs) still needs to be developed because the resilient design modification has a taper angle and space with different sizes and locations.

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DOI: 10.46934/ijp.v4i2.160

Management of denture stomatitis in removable dentures wearers

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ABSTRACT
Denture stomatitis (DS) is a pathological change in the oral mucosa that commonly occurs in denture users, which is characterized by an inflammatory reaction and erythema in the oral mucosa that is in contact with the denture. Clinical manifestations often include red lesions due to excessive occlusal trauma, frequently occurring in the palatal mucosa region. Loose and unstable prosthesis use can also be a predisposing factor for DS. This paper discusses cases of DS in patients with complete dentures (CD) and partial complex dentures. Chronic irritation due to heavy traumatic occlusion results in reduced stability of dentures. The fabrication of CD with proper vertical dimension setting and selection of smaller teeth elements can reduce progressive alveolar bone resorption. The use of topical gel medication like *Oxyfresh* can be an alternative in the clinical management of DS cases. Control of systemic conditions, especially in the presence of comorbidities, is crucial to minimize the risk of DS occurrence and expedite the healing process if it does occur. Maintaining oral hygiene and denture cleanliness are also key factors for the success of optimal denture care.
Keyword: denture stomatitis, occlusal trauma, denture stability, alveolar bone resorption, topical dental gel

INTRODUCTION

Oral mucosal lesions associated with the use of removable dentures are commonly occurs after insertion of dentures. The reaction can be acute or chronic reactions to microbial plaque on the denture, allergic reactions to denture base materials, or mechanical trauma from the denture. Acute reactions include traumatic ulcers, allergic reactions to denture base material, or acute infections. Chronic reactions are more common, such as denture stomatitis (DS) due to chronic infection or trauma, *angular cheilitis*, *denture irritation hyperplasia, flabby ridge*, and *oral carcinoma*. DS is one of the common issues encountered by denture wearers. In DS, pathological changes in oral mucosa occur over a period of time and are associated with the pressure exerted by the denture on the surrounding tissues. This is characterized by inflammatory reactions and erythema in the oral mucosa area, especially areas that are in contact with the denture. DS generally occurs in more than 50% of the denture-wearing population, and the incidence of DS is higher in partial denture wearers than in complete denture wearers.[1,2]

The DS is a multifactorial condition involving an interaction between local and systemic predisposing factors, without specific predilection for races and gender. The causes of DS include infection, trauma, and the host's defense response to oral cavity conditions and dentures. The immunological condition of denture wearers greatly influences the occurrence of DS. *Candida albicans* is the microorganism that causes DS. Poorly fitting dentures also increase mucosal trauma. Only a small percentage of patients complain of pain, itching, or burning sensation. Despite the high prevalence of DS, it is generally asymptomatic.[3,4]

Comprehensive and effective management of DS consists of maintaining denture hygiene, providing antifungal treatment, and correcting denture fabrication errors. To prevent or minimize the progression of lesions, patients need regular checkups with a dentist to examine the oral cavity and dentures. It is important for healthcare professionals to have knowledge of oral cavity and denture examination so that they can make accurate diagnoses and provide appropriate management.[1,5]

LITERATURE REVIEW

Denture stomatitis, also known as *chronic atrophic candidiasis* or *prosthetic stomatitis*, is characracterized by inflammation and redness of the oral mucosa beneath dentures (usually the palatal mucosa covered by an upper denture). DS is one of the common issues encountered by denture wearers and characterized by erythema, edema, often pinpoint petechiae (small red spots) on the palatal mucosa covered by the denture-bearing surface. The most common location for DS occurrence is the palatal mucosa, and it rarely occurs on the lower jaw due to protection by saliva flow. DS primarily occurs when dentures are worn throughout the night and not removed during sleep. It is more prevalent in women than in men. According to several studies in Switzerland, the prevalence of DS 11-67%.[3,4-6]

The DS is clinically classified into three types, namely type I, II, and III (Fig.1). Type I shows local-

DOI: 10.46934/ijp.v4i2.211

ized inflammation or pinpoint hyperemia. Type I lesions are caused by occlusion of the salivary ducts by dentures. Type II is characterized by diffuse erythema. Type III is marked by non-neoplastic papillary hyperplasia, with varying levels of inflammation. The papillary hyperplasia is typically localized on the central hard palate, presenting as nodular or mossy in appearance. There is an association between simple localized inflammation (DS type I) with ill-fitting dentures, as well as related with irritation and trauma. Ill-fitting dentures increases the risk of DS. The more extensive form of DS manifests as granular inflammation, which is found to be associated with poor oral hygiene and Candida infection. After one year of use, the overall occurrence of DS reaches 64%, with the severity rate of type I being the same as type II. However, patients with conventional dentures are more prone to DS due to occlusal pressure. Type II lesions are confined to the mucosa that experiences trauma from denture use, and type III lesions have characteristics almost identical to type II but with extensive granular-like lesions on the mucosa (inflammatory papillary hyperplasia).[7,8]

Figure 1 Classification of DS (Source: Budtz-Jørgensen E. Oral mucosal lesions associated with the wearing of removable dentures. J Oral Pathol 1981;10(2):65–80).

The risk factors for DS are multifactorial due to the interaction of local and systemic predisposing factors. Local factors such as local trauma from ill-fitting dentures, hyposalivation which leads to an increased attachment of *C.albicans* to the oral mucosa, and this attachment also occurs on the denture. Poor oral hygiene and wearing dentures overnight, high-carbohydrate diet, smoking, and alcohol consumption are local factors that can increase the risk of DS. In addition to local factors, conditions such as advanced age, endocrine dysfunction, nutritional deficiencies (iron, folic acid, vitamin B12), neoplastic conditions, immunocompromised and immunosuppressed states, acute leukemia, agranulocytosis, as well as antibiotic therapy are systemic factors that can increase the occurrence of DS.[6,7]

Pathogenesis

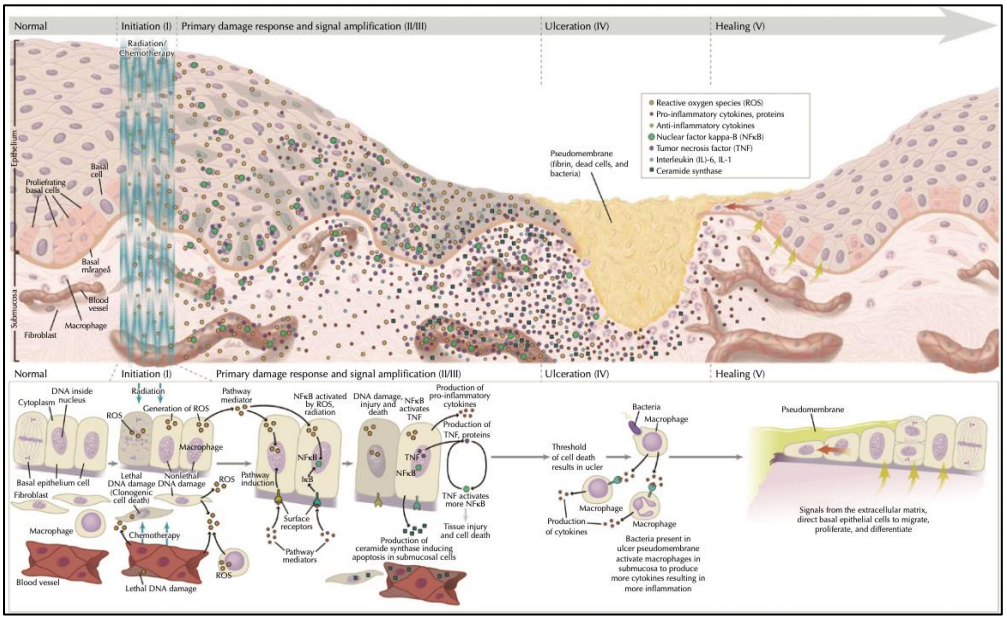
The clinical manifestation of DS includes changes in soft tissue known as flabby mucosa. *C.albicans* is the causative agent and is considered the most pathogenic and invasive species. These changes are related to its dimorphic ability, alternating between forming hyphae and yeast as a prerequisite for biofilm formation. The hyphal form is more frequently found in DS patients, and *C.albicans* triggers a faster inflammatory response, characterized by the release of antigens, toxins, and irritants from the denture plaque, leading to the occurrence of DS.[4,8]

The formation of inflammatory lesions in the oral mucosa is a complex process that follows a five-phase model proposed by Sonis et al (Fig.2). These five phases occur sequentially, starting with initiation, signaling, amplification, ulceration, and healing. Initially, tissue injury occurs due to an underlying etiology, resulting in the death of basal epithelial cells and the formation of reactive oxygen species (ROS). The initiation phase occurs after the release of molecules generated by the damage to basal epithelial cells, submucosa, and endothelium. Following initiation by ROS and the innate immune response further damage cell membranes, stimulate macrophages, and activate several pro-inflammatory transcription factors. These factors express genes that lead to spikes in pro-inflammatory cytokines such as TNF-a, IL-6, IL-1, and Cox-2, as well as the expression of other genes that cause adhesion molecule expression and angiogenesis. After the signaling phase, an amplification phase occurs to strengthen the signal. In this phase, there is an upregulation of TNF-a regulation that reinforces the inflammatory response, damaging fibronectin, leading to increased macrophage activation. The inflammatory response causes direct apoptosis of basal and submucosal epithelium and progresses to the ulceration phase in the mucosa. In the final stage, the epithelium undergoes healing through proliferation, migration, and differentiation of the epithelium stimulated by the extracellular matrix. After the healing phase, the oral mucosa returns to normal, but patients are at risk of recurrence due to residual angiogenesis.[8-10]

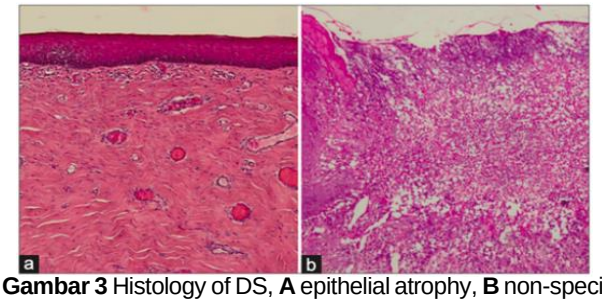
The histopathological changes in DS are non-specific and vary according to the severity of the lesions. In DS, there are epithelial changes such as parakeratosis, lack of keratinization, epithelial atrophy, epithelial hyperplasia, and acanthosis, as well as chronic inflammation in the lamina propria layer (Fig.3). Based on electron microscopic studies of type II and III lesions, no keratohyalin granules were found in the superficial layer, but there was an increase in intracellular space in the stratum spinosum, along with infiltration of mononuclear cells in the epithelium.[10]

Mycological and immunological studies support

DOI: 10.46934/ijp.v4i2.211



Gambar 2 Pathogenesis of the oral inflammation (Source: Glick M. Burket's oral medicine. Shelton, CT: People's Medical Publishing House; 2015).



Gambar 3 Histology of DS, **A** epithelial atrophy, **B** non-specific ulcer (Source: Budtz-Jørgensen E. Oral mucosal lesions associated with the wearing of removable dentures. J Oral Pathol 1981;10(2):65–80.

the association between infection and DS. Infection is primarily caused by the contamination of the denture surface by fungi, especially *Candida*. Poor denture hygiene is a significant risk factor for DS. On the surface of dentures with poor hygiene, there is biofilm attachment and accumulation of pathogenic plaque (Fig.4). In biofilm and plaque, there are bacteria and yeast that colonize the mucosa. Contaminants in biofilm and yeast cells also play a role in the development of DS. Studies have identified 82 bacterial phylotypes and 3 fungal species from denture swabs. Among the fungal species, *C. albicans* is the only species found in the denture biofilm of DS patients.[9,10]

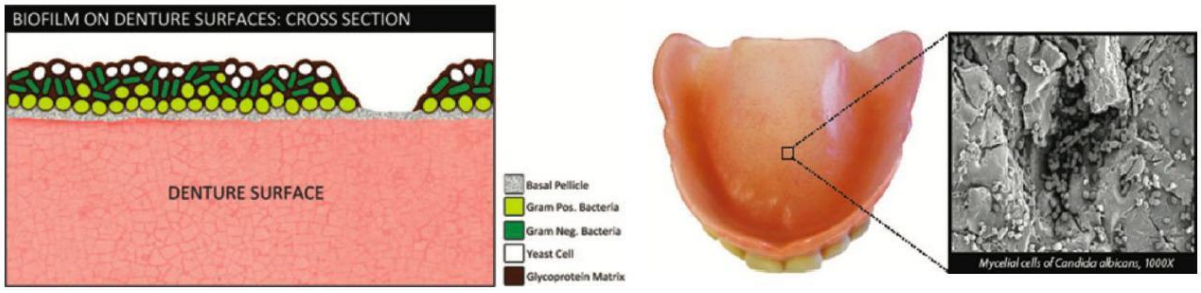
Diagnosis

The diagnostic approach to DS involves taking a medical history and conducting a clinical examination (identifying signs and symptoms) with the aim of identifying the direct cause of DS (infection, trauma, or allergy), as well as predisposing factors such as oral hygiene, denture materials, denture use, and systemic diseases. The DS is most often asymptomatic or without symptoms, with only some patients complaining of pain, a burning sensation, or itching. DS is primarily diagnosed during clinical examinations as inflammation of the mucosa in contact with dentures, characterized by erythema and edema.[4,7]

Demographic factors such as age (elderly individuals), female gender, smoking, and comorbid conditions that affect the immune system could provide supportive data for the diagnosis of DS. Factors related to denture use, such as ill-fitting placements that worsen trauma and irritation of the oral mucosa, denture aging, the use of partial dentures, poor denture care and hygiene, and continuous denture wearing. Host vulnerability plays a role in DS, increasing with age and the patient's medical conditions, especially when taking certain medications as part of their treatment. Immunocompromised patients or those undergoing immunosuppressive therapy are more susceptible to *Candida* infections. One crucial aspect of DS management is oral hygiene. Over time, the denture surface deteriorates, leading to an accumulation polymicrobial complex and resulting in infections.[7,8]

Several supporting diagnostic alternatives can be conducted through mycological and immunological examinations, such as mycological examination, culture, and salivary counts.[4,9] The confirmation of a DS diagnosis related to *Candida* infection is based on the quantitative estimation of fungal growth on the oral mucosa and denture surface. Assessment can be done through culture or direct microscopy. Culture specimens and microscopic tests

DOI: 10.46934/ijp.v4i2.211



Gambar 4 Denture surface with poor hygiene (Source: Gendreau L, Loewy ZG. Epidemiology and etiology of denture stomatitis. J Am Coll Prosthodont 2011;20(4):251–60).

are taken by scraping the palatal mucosa or dentures. *Candida* infection is confirmed when dentures and mucosa are filled with fungi. Quantitative estimation through culture is obtained from a miniaturized culture test system, which serves as a cost-effective alternative to swab examination for candidiasis screening.[9]

Diagnosing DS due to allergies is established through immunological testing. Immunological testing is only relevant if infection or trauma has been ruled out, and if the clinical history and lesion appearance indicate an allergic reaction, such as a burning sensation, diffuse erythema, and edema of tissues in contact with the dentures. Positive results in delayed hypersensitivity skin tests and denture base materials indicate mechanical irritation or microbial contamination. Patients should be referred to a dermatologist for a skin test. Therefore, persistent DS may indicate systemic disease involvement and should be treated immediately.[4,8-10]

Management

The management of DS is a comprehensive approach, starting with the identification of local and systemic predisposing factors, eliminating errors in denture use, maintaining good oral hygiene and denture care, and adequate antifungal therapy. Education about dental and oral hygiene, as well as the care of dentures, is a key element in the success of DS therapy.[7-9] One study suggests that good oral hygiene and denture care, along with removing dentures before sleeping, are effective ways to manage DS. Additionally, the appropriate use of antifungal agents is also effective in most cases of DS.[10] Therefore, controlling underlying predisposing factors, maintaining oral and denture hygiene, and using appropriate antifungal treatments are considered effective for DS.[11]

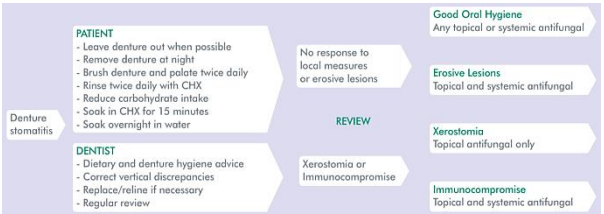


Figure 5 Protocol for the management of DS in primary care (Source: Elad S, Thierer T, Bitan M, Shapira MY, Meyerowitz C. A decision analysis: the dental management of patients prior to hematology cytotoxic therapy or hematopoietic stem cell transplantation. Oral Oncol 2008;44(1):37–42).

The maintaining oral cavity cleanliness can be achieved through dental health education (DHE), which involves brushing teeth in an up and down motion using a soft-bristle toothbrush. Avoiding local factors that trigger DS, such as smoking and wearing dentures overnight especially during sleep, is essential. According to The American College of Prosthodontists (ACP), dentures should be cleaned by brushing the prosthetic teeth outside the oral cavity at least once a day, using a specific non-abrasive toothpaste or hand soap. Ensure thorough cleanliness of the dentures, especially on surfaces that come into contact with the mucosa and gums. Afterward, dentures need to be disinfected with 0.5-2% (w/v) sodium hypochlorite solution. This solution has antimicrobial properties due to the dissociation of hydroxyl ion (OH-) and chloride ion (Cl-) in water, leading to the degradation of microbial cell walls. Disinfection with sodium hypochlorite should be done for ≤10 minutes to prevent surface damage to polymethyl methacrylate. Dentures should also be removed from the oral cavity when sleeping, should not be worn continuously 24 hours a day, and should be soaked in clean water when not in use.[10]

Improving denture fit is achieved by smoothing rough areas, and using tissue conditioner which can be applied to the denture base in areas affected by DS lesions. The objective is to reduce irritation and promote healing in the soft tissues surrounding the dentures. If there is significant contact, occlusal correction should be performed, such as selective grinding, by reshaping the occlusal surface of the teeth through smoothing to establish adequate contact between the upper and lower jaw teeth. The goal of selective grinding is to ensure that the dentures do not press on the palatal mu-

DOI: 10.46934/ijp.v4i2.211

cosa or other areas, and making the new dentures more comfortable to wear. Additionally, the addition of dental gel (Oxyfresh dental gel) can be done to expedite the healing process of mucosa affected by DS.[11]

Antifungal therapy as a treatment for DS is considered effective, when there is no improvement after eliminating predisposing factors and maintaining good oral and denture hygiene. Medication therapy is not recommended as a first-line treatment, because DS tends to recur if not accompanied by improved oral and denture hygiene. However, antifungal therapy is administered to immunocompromised patients. Commonly prescribed antifungals include *Nystatin, Miconazole, Amphotericin B, Fluconazole, Clotrimazole, Ketoconazole,* and *Chlorhexidine*. Topical antifungals are preferred over systemic because they have fewer side effects. Topical antifungals can be administered in various forms such as suspension, tablets, lozenges, creams, powders, and gels.[4,7,8] Typically, antifungal treatment is given for 14 days.

CASE

Case-1

The patient came to the dental clinic at Atma Jaya Hospital with a complaint of pain in the upper jaw gums when wearing dentures two months prior to admission. The pain was experienced after wearing dentures for two months. The pain was described as stabbing and does not radiate. The patient has not taken any medication for the current complaint. There was no noticeable swelling or redness in the gums. The patient had a history of heart disease for the past two years, but does not regularly take routine medications. General status examination showed stable hemodynamics, with blood pressure at 110/70 mmHg, heart rate 80 beats per minute, respiratory rate 20 breaths per minute, afebrile temperature, and overweight nutritional status (BMI: 23.6 kg/m2, Asia-Pacific criteria). No abnormalities are observed on extraoral examination. On intraoral examination, significant findings were found such as fissured tongue, edema and erythema on posterior mucosa of tooth 27, and gingival recession on teeth 31-33 and 41-45.

Antifungal medication	Dosage and formulation	Treatment protocol
Fluconazole	50 mg oral tablet	Once daily; 14 days
Miconazole	2% Gel applied to denture intaglio	Three times daily; 14 days
Nystatin	215,000 IU powder to denture intaglio	Three times daily; 14 days
Nystatin	1,000,000 IU mouth rinse/denture soak	Twice daily; 28 days
Amphotericin B	10 mg lozenges	Four times daily; 14 days
Itraconazole	100 mg oral capsules	Twice daily; 14 days

Figure 6 Commonly Antifungals Medication for DS.McReynolds DE, Moorthy A, Moneley JO, Jabra-Rizk MA, Sultan AS. Denture stomatitis-An interdisciplinary clinical review. J Prosthodont. 2023;32(7):560–70.

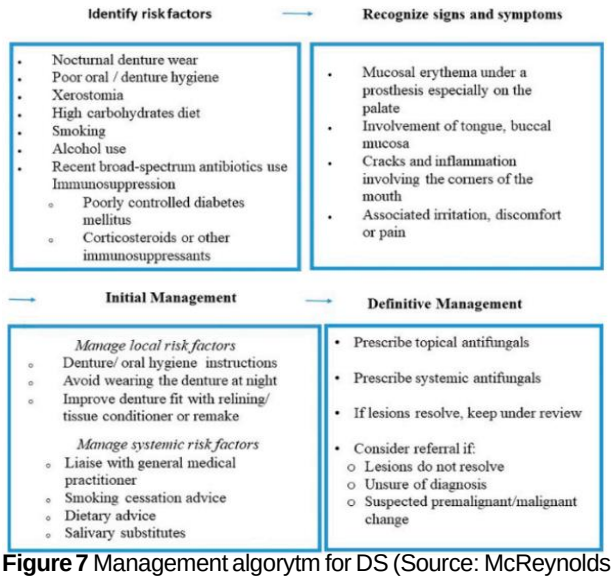


Figure 7 Management algorytm for DS (Source: McReynolds DE, Moorthy A, Moneley JO, Jabra-Rizk MA, Sultan AS. Denture stomatitis-An interdisciplinary clinical review. J Prosthodont 2023;32(7):560–70.

Figure 8 The patient's teeth in the first visit, using acrylic RPD

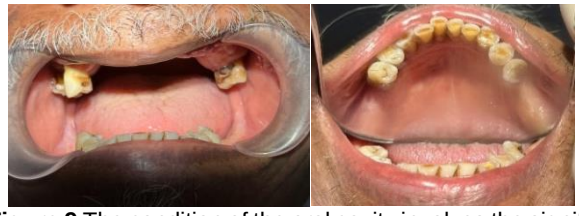


Figure 9 The condition of the oral cavity involves the significant loss of teeth in the upper and lower jaws

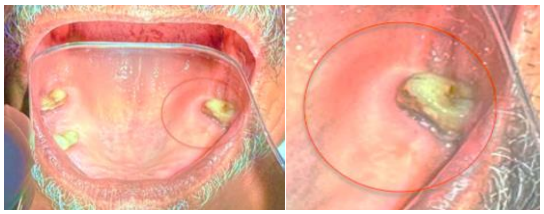


Figure 10 Clinical appearance of DS on the posterior teeth 27 of the left upper jaw.

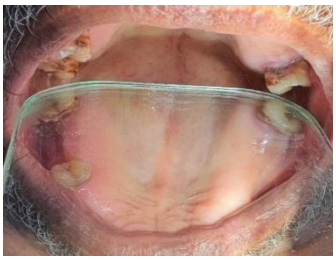


Figure 11 Clinical appearance of mucositis around 2-3 weeks after selective grinding

DOI: 10.46934/ijp.v4i2.211

Figure 12 During follow-up

The denture appears unstable and fits loosely in the oral cavity, which could be one of the contributing factors to the occurrence of DS.

CASE II

Patient came in for a routine check-up for his dentures, which have been worn for more than 5 years. Currently, there are no complaints about the dentures, except for occasional erythema on the palate, but there was no pain. Extraoral examination appears normal with no asymmetry, and palpation around the lips and nose area is not painful and appears normal. Intraoral examination reveals poor oral hygiene, multiple missing teeth, and the presence of plaque and calculus accumulation, but without accompanying pain. There is a total tooth loss, only erythema is observed, without any pain.

Figure 13 Patient's intraoral and extraoral condition

Figure 14 Patient's old denture

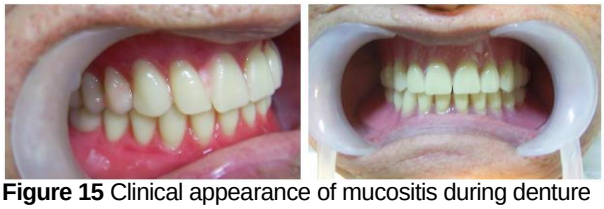


Figure 15 Clinical appearance of mucositis during denture fabrication (left), after denture installation (right).

In this case, there is severe alveolar bone resorption, especially in the anterior upper jaw area, because the prosthesis is loose and heavy occlusal load. Furthermore, the patient's poor oral hygiene is evident from the dirty appearance of the old dentures and the presence of calculus on them. The clinical finding in this patient is mucosal erythema, mainly in the anterior and posterior left palatal areas. Mucosal erythema occurs due to excessive occlusal trauma and the ill-fitting old dentures, considering that some teeth have been extracted, leading to a change in denture design. This causes chronic irritation to the posterior left palatal mucosa.

MANAGEMENT

For case-I, combination therapy was carried out using topical ointments which led to better healing in addition to adjusting the rough denture surface. Case-II, on the other hand, involved the fabrication of a new denture with an extended posterior wing base area to reduce occlusal load. In addition, a tooth-arrangement technique was also performed, whereby the artificial teeth were positioned over the alveolar lingir to reduce progressive alveolar resorption.[5,7] In addition, a new denture is also recommended to improve DS.

DISCUSSION

The DS often does not cause the initial lesions to be painful as reported by patients. Some references state that DS occurs in denture wearers, especially in complete dentures, due to plaque accumulation, trauma from poorly fitting dentures, microbes on the denture surface, and poor oral hygiene. Trauma from dentures can be eliminated by observing the dentures using *pressure indicating paste* (PIP), which is indicated by areas where the PIP is removed from the dentures, signifying excessive trauma. The best management of DS involves improving the denture by smoothing the denture base surface with a stone bur and adjusting it for balanced occlusion and articulation.[2,3]

Education on denture use is highly necessary, such as maintaining denture hygiene, especially by removing them at night and cleaning them after meals, and providing denture cleaner, that are effective therapies to reduce plaque and microorganism accumulation. In addition, antifungal medications should be administered, and improvements to the dentures should be made, such as application of tissue conditioner and allowing the dentures to rest. Tissue conditioner can be applied to the denture base in areas affected by DS lesions. The use of tissue conditioner should be continued for one week and re-evaluated. Furthermore, it is necessary to observe improvements in denture occlusion and articulation. If there is excessive contact, occlusal correction and adjustments in chewing movements may be required. Selective grinding and polishing of the dentures are performed to prevent them from pressing on the palatal mucosa and other areas. If necessary, dental gel can be added

DOI: 10.46934/ijp.v4i2.211

to expedite the healing process and recovery. If left untreated, DS can cause pain and palatal inflammatory papillary hyperplasia, resulting in ill-fitting dentures in the future. Correcting loose dentures through adjustments and smoothing the denture surface can alleviate discomfort for denture wearers. Reducing the load on denture-bearing areas is also essential.[8,10]

Microwave irradiation has become a fast, economical, and effective method that works on *Candida* by exposing them to radiation using 2450 MHz waves, 3540 watts, for 8 minutes. This will change the energy, causing distortion in the dentures. Photodynamic therapy is also an alternative treatment for DS. Photosensitizing agents and exposure to specific wavelengths, along with binding to free radicals, result in cell membrane lysis and protein inactivation. Advising patients to limit unhealthy habits such as smoking and choosing a diet with restricted carbohydrates can reduce oral candidiasis.[8,9]

It is summarized that denture stomatitis is an inflammation of the oral mucosa, which contacts with dentures. The causes of DS are multifactorial, primarily due to chronic trauma from denture use, *Candida* infection, and poor oral and denture hygiene. DS is generally asymptomatic but can lead to complaints such as pain, a burning sensation, or itching. The diagnostic approach for DS involves recognizing the signs and symptoms of DS, as well as predisposing factors, to determine the direct cause of DS, which can be infection, trauma, or allergy. Diagnosis confirmation is done based on suspected causes, such as culture or microscopic examination of scrapings from the palatal mucosa or dentures, or immunological tests.[6]

Effective management of DS depends on the patient's compliance in maintaining oral cavity and denture hygiene. The DHE are the cornerstone of successful treatment of DS, involving mechanical cleaning of dentures using a soft-bristle toothbrush and non-abrasive soap or special denture paste, soaking dentures in a disinfectant solution, removing dentures from the oral cavity at night before sleep, and control to a prosthodontist about denture-related trauma and remove microbial deposits. The administration of antifungal agents improves healing in most DS cases, especially in immunocompromised patients, so DS therapy is based on the condition of intraoral lesions, oral and denture hygiene, and the patient's systemic condition.

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DOI: 10.46934/ijp.v4i2.211

The efficacy of oral appliances treatment for obstructive sleep apnea

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ABSTRACT
Obstructive sleep apnea (OSA) is a sleep disorder caused by upper airway obstruction. There are about one billion people worldwide affected by OSA; in the past decade, the number of people who seek treatment for OSA is increasing. Although *continuous positive airway pressure* (CPAP) is the gold standard for OSA treatment, the dentist also has a role in treating OSA using oral appliances (OA), especially for those who do not want to be treated using CPAP. However, the efficacy of OA treatment for OSA is varied so further study is needed. This scoping review ia aimed to evaluate the efficacy of OA treatment for OSA on adult patients with different severity based on the *apnea-hypopnea index* (AHI) which is classified as a mild, moderate, and severe group. It is concluded that OA effectively reduces the symptoms of OSA. It must be noted that objective examination through the AHI evaluation shows that AHI reduction is affected based on the OSA and BMI classification. Patients with high BMI demonstrated a smaller reduction in AHI, thus showing low effectiveness of OA.
Keywords: obstructive sleep apnea, adult, oral appliances, continuous positive airway pressure, treatment

INTRODUCTION

Obstructive sleep apnea (OSA) can be defined as a health problem where respiratory disturbance occurs during sleep.[1,2] OSA's main characteristic is the presence of partial or complete airway obstruction during sleep.[2] Numerous symptoms occurred during OSA, such as irregular loud snoring, grunting, gasping, unusual sleeping breath sounds, and long pauses in breathing during sleep. Other symptoms also include excessive sleepiness, fatigue, obesity tendency, headaches, and changes in emotion or behavior. An untreated OSA may cause 20 times increase in the risk of a heart, 3 times increase in the risk of a stroke attack, uncontrolled weight gain, hypertension, decline in memory, alertness, coordination, and even death.[3,4]

The predisposing factors for OSA are obesity, male gender, and age.[2] OSA is generally more common in men than women and while it can occur at all ages, even at birth, OSA is more common in middle age individuals.[3] Prevalence of OSA is 3% in women and 10% in men aged 30-49 years, 9% in women, and 17% in men aged 50-70 years.[4] The estimated global prevalence of OSA is nearly one billion persons.[5]

As mentioned above, an untreated OSA may cause a variety of negative effects. Therefore, proper management of OSA treatment is vital. The goal of OSA treatment is to reduce any symptoms that occur due to OSA and improve respiration by widening the respiratory tract or oropharynx, either by surgery or by opening the airway. Common treatments for OSA are the use of continuous positive airway pressure (CPAP) machine, soft tissue surgery of the throat, and the use of oral appliances (OA).[1] Dentist can also treat OSA by the means of OA fabrication.

The severity of OSA can be measured by using the apnea-hypopnea index (AHI) which is calculated by using polysomnography (PSG). Based on the AHI, mild OSA is at AHI 5-14, moderate OSA is at AHI 15-29, and severe OSA is when AHI more than 30.[4] According to the American Academy of Sleep Medicine, OA, specifically, mandibular advancement device (MAD), can be used for OSA treatment in mild to moderate OSA.[6] CPAP is the main treatment for patients with severe OSA, however, the use of CPAP is usually quite difficult for patients. If the patient cannot receive CPAP therapy, the use of OA can be considered to use with combination of treatment therapy with other fields like surgery.[1] According to existing studies, the effectiveness of OA itself varies greatly; 57-81% for mild and moderate OSA, while for severe OSA it is 14-61%.[1,4] This varying success rate of OA treatment is also influenced by various factors such as AHI, body weight based on body mass index (BMI), gender, and age.[4]

There are three types of OA, namely MAD, tongue retaining device (TRD), and oral positive airway pressure appliance (OPAP) (Fig.1). The mechanism of how OA works is to place the mandible and tongue in a protrusive position so that the oropharyngeal space expands and prevents the upper respiratory tract from collapsing.[6,7] MAD is a device that holds the mandible in a protrusive position. Usually, this device is made of acrylic with metal loops. In addition to MAD, there are also other

DOI: 10.46934/ijp.v4i2.246

devices that can be used for the treatment of OSA, namely TRD. This tool is shaped like a suction cup to position the tongue anteriorly; the patient is instructed to bite the device so that the tongue is held in the front position. However, this device is less comfortable to use when compared to the MAD. Contraindications of MAD and TRD are patients who cannot breathe through the nose. Besides MAD and TRD, another OA device known as OPAP can also be used for OSA treatment. This device is shaped like a retainer that is placed in the mouth and is connected to the CPAP tube and the machine. OPAP does not require head equipment like CPAP and since this device does not use a mask, it does not irritate the skin. The downside of using this device is excessive salivary production thus it is less comfortable for the patient. Also, patients with temporomandibular joint disorders are not recommended to use these devices.[3]

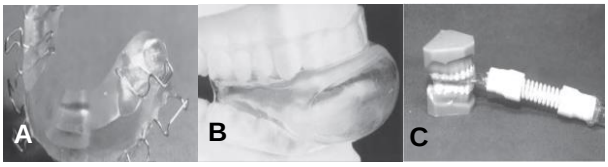

Figure 1A The MAD, **B** the TRD, **C** the OPAP.[3]

Today, OSA is a common health problem. The global prevalence of OSA is enormous, estimated at almost one billion. An untreated OSA can cause various kinds of negative impacts. Therefore, clinicians, including dentists, should pay more attention to the management of OSA so that the patient's quality of life can be maintained or even improved. The use of OA appliance is one of the OSA treatments that can be performed by dentists. The purpose of this scoping review is to find out how effective OA is for treating OSA based on the existing literature. In addition, this scoping review also aims to increase the dentists' knowledge and understanding of OSA and OA.

LITERATURE STUDIES

This scoping review paper summarizes and evaluates the results of existing studies on the effectiveness of the oral appliance for treating sleep apnea. The steps taken in this paper are determining study questions, conducting study selection, collecting data in a chart, and compiling a summary as well as evaluating the results of the study. The writing of this scoping review is based on the guidelines from Arksey and the Preferred Reporting Items for Systematic Review Extension for Scoping Review (PRISMA-ScR).[8,9]

The research question in this scoping review is *How effective oral appliance in reducing the symptoms of sleep apnea?*. The selected population is adult patients with OSA. The concept used is treated with an OA. The context set is the effectiveness of the appliance.

The literature search which is relevant to the research questions were carried out using the internet from three sources, namely PubMed, Wiley Online Library, and EBSCO. The keywords used to search were ("oral appliance" AND "sleep apnea" OR "sleep apnea"). The literature searched was literature published 2016-2021, in English, and carried out on adult people. The inclusion and exclusion criteria used are shown in table 1.

After the articles were searched according to the criteria, screening was carried out because there were some duplicated articles. Screening is also done by reading abstracts in each journal to pay attention to the inclusion and exclusion criteria. Appropriate literature will be included in this scoping review. The literature search yielded a total of 8 articles with PubMed with 38 articles, EBSCO with 28 articles, and Wiley literatures with 21 articles. Then duplicated articles were checked and there were 10 duplicated articles. The exclusion of literature that is not relevant to this scoping review was also carried out in terms of titles and abstracts leaving 57 articles. After obtaining the relevant literature, the literature was read again and 13 articles did not match the predetermined criteria so they were eliminated. The final results obtained eight articles that will be used in this scoping review. The results of the literature used in this scoping review can be seen in Table 1.

Table 1 Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Time	Published January 2016 – September 2021	Published before January 2016
Language	English	Other than English
Subject	Sleep apnea in adult patient	Pediatric patients (under 18 years), experimental animals, laboratory samples
Concept	Treatment using oral appliance	Treatment using CPAP or surgery
Context	Efficacy of oral appliance reported	Efficacy of oral appliance unreported
Design	Randomized clinical trial, prospective study, retrospective study, cross-sectional study	Case report, finite element analysis, systematic review, meta-analysis, literature review
Full Text	Available	Not available

DOI: 10.46934/ijp.v4i2.246

Table 2 The efficacy of oral appliances treatment for obstructive sleep apnea in the past five years

No	Author (Year), R.Design, OSA Classif,	Objective	Result	Conclusion
1	Guillaume et. al. (2021)[7], Retrospective, Samples: 347, Moderate Severe	To determine the predictive factors of OA efficacy. The secondary objective was to measure the efficacy rates and determine OAs' tolerance and dropout	The 50% AHI reduction rate after OA was 65.2%, the AHI ≤5/hr rate after OA was 26.1%, and the <50% AHI reduction and residual AHI > 10/hr rate was 50.1%. OA significantly reduced AHI (−14.9/hr, P<.0001). In 7.8% of patients, AHI increased with OA. Seven patients (1.5%) experienced adverse effects, 37 (7.8%) patients stopped using OA mainly because of its ineffectiveness.	OA is an effective and well-tolerated treatment for moderate to severe OSA. This treatment was effective for reduction of the AHI ≥50% in ⅔ of cases studied and it should be considered in more cases.
2	Okuno et. al. (2020)[4] Cross-sectional, Samples: 442, Mild moderate severe	The purpose of this cross-sectional study was to investigate the success rate of OA for OSA patients.	After OA treatment, the mean AHI decreased from 22.6 ± 13.8 to 10.0 ± 10.2/h and the mean rate of decrease in the AHI was 52.5 ± 38.4%. The success rate of OA treatment decreased according to the increase in OSA severity, obesity level (higher BMI), and older age.	OA can reduce 52.5% AHI. The treatment success rate of OA on multiple criteria according to OSA severity, BMI, and age
3	Lu et. al. (2020)[10] Cross-sectional, Samples: 30, Mild Moderate	To investigate the clinical effectiveness of adjustable oral appliance on older adult patients with OSAS.	By using oral appliance, AHI had decreased from (27.65±1.31) per hour to (6.74±0.75) per hour (P<0.05); the maximum apnea time (MAT) decreased from 43.82±2.69 to 21.37±3.18 s (P<0.05). CBCT showed that the minimal sagittal diameter, the volume of the palatopharynx, and volume of the glossopharynx significantly increased.	OA had considerable clinical efficacy and comfort in older adult OSAS patients by enlarging the palatopharynx and glossopharynx.
4	Byun et. al. (2019)[11] Prospective, Samples: 50, Moderate Severe	To determine the efficacy of OAs for the first-line treatment of Korean patients with moderate or severe OSA.	The patients were aged 47.4±12.1 years (mean±SD) and their AHI at baseline was 29.7±10.9/h. After OA treatment the AHI had reduced by 63.9± 25.8%, with the reduction was similar between the moderate and severe OSA. Overall 31.1% of the patients achieved a normal AHI (<5/h), and 64.4% had an AHI of ≤10/h after the treatment. The body mass index (BMI) was the most reliable factor for predicting the percentage reduction in the AHI	The OAs were effective in patients with moderate or severe OSA. The OAs reduced the mean AHI to 63.9% of the baseline value, and this reduction was influenced by the BMI.
5	Skalna et. al. (2019)[12] Clinical experimental, Samples: 58, Mild Moderate Severe	To verify the effectiveness of current OSA treatment by objective measurements, and to assess by means of a questionnaire patients' satisfaction with OA.	Average AHI reduction in the entire group was 10.4; 31% of patients experienced AHI reduction by at least 50%. Significant AHI reduction was proven when using the appliance. Appliances affect the reduction of AHI and patients tolerate the appliances well.	OA complement positive-pressure treatment and do not interfere with it in any way. OA can be used if the patient refuses to do CPAP treatment.
6	Enrique et. al. (2017)[13] *Case-control,* Samples: 35, Moderate Severe	To investigate outcomes including efficacy, quality of life, and levels of inflammatory markers of a MAD for moderate-to-severe OSA.	At 6 months, the MAD significantly improved AHI and lowest oxygen saturation (P<.01), non–rapid eye movement (N)1 and N3 sleep stages (P<.05), ESS score (P<.05), FOSQ total score (P<.01), interleukin 1b (P<.05), and TNF-a (P<.01) compared with the untreated group. In the overall, moderate, and severe OSA groups, 63.3%, 75%, and 50%, respectively, achieved at least a good response	The use of a MAD significantly improved polysomnographic parameters, quality of life, and some inflammatory markers (CRP, IL-b, and TNF-a). MAD may be a viable alternative therapy in with moderate-to-severe OSA who refuse continuous positive airway pressure.
7	Nikolopoulou et. al. (2017)[2], Randomized placebo-controlled trial, Samples: 219, Mild Moderate	To compare the effects of a MAD with those of nasal continuous positive airway pressure (nCPAP) on self-reported symptoms of common sleep disorders and sleep-related problems in mild and moderate OSAS patients	The MAD group showed significant improvements over time in symptoms of common sleep disorders and sleep-related problems (P: 0.000–0.014). These improvements in symptoms were, however, not significantly different from the improvements in symptoms observed in the nCPAP and placebo groups (P: 0.090–0.897).	There is no significant difference between MAD & nCPAP in their positive effects on self-reported symptoms of common sleep disorders & sleep-related problems in mild and moderate OSAS; may be a result of placebo effects
8	Nordin et. al. (2016)[1] Cross-sectional Samples: 738	To survey the care and patient experiences and the self-reported effectiveness of OSA treatment with an OA incorporating mandibular advancement	Treatment with OA gave relief of symptoms in 83%. Quality of life, somatic and cognitive symptoms improved significantly in patients who used the appliance frequently (P < 0.001). Daytime sleepiness decreased significantly (P < 0.001). Treatment satisfaction and willingness to recommend a similar treatment to a friend were high (>85%).	User of OA frequently reported improvement in quality of life, somatic, and cognitive symptoms. Excessive daytime sleepiness was reduced in the majority of the patients under treatment.

DOI: 10.46934/ijp.v4i2.246

DISCUSSION

This scoping review aims to evaluate the efficacy of oral appliance treatment for OSA in adult patients with different severity based on the AHI in the last five years. In the eight literatures that match the inclusion criteria, there are differences in research design, OSA classification, and evaluation methods, therefore these can lead to inconsistencies in the summary.

Judging from the research design in the eight selected literatures, three literatures are cross-sectional[1,4,10], one prospective[11], one retrospective[7], one clinical experimental[12], one case-control[13], and one randomized placebo-controlled trial literature[2]. Based on the classification of OSA, two literatures evaluate mild, moderate, and severe OSA[4,12], two literatures evaluate only mild and moderate[2,10], three literatures evaluate moderate and severe[7,11,13], and the other one does not evaluate the AHI classification[1]. In these eight literatures, there were researchers who evaluate subjectively[1], objectively[4,7], and both[2,10-13]. These differences cause the result and conclusions to vary.

Nordin et.al evaluate that subjectively, OA can reduce symptoms in 83% of respondents. Quality of life and cognitive are also improved in patients who routinely use OA.[1] Okuno et al and Skalna et al objectively evaluate the effectiveness of OA against OSA in mild, moderate, and severe classification.[4,12] The results of Okuno et al's study showed that treatment with OA could reduce AHI from 22.6±13.8/h to 10.0±10.2/h with an average reduction of 52.5±38.4%, in addition, Okuno also found that OA success decreased as the increasing of OSA severity, BMI, and age.[4] The study conducted by Skalna et al said that OA can reduce AHI by as much as 10.4/h which is almost similar to the study conducted by Okuno. AHI reduction of 50% was found in 31% of patients, 14% did not experience any reduction, and the rest experienced a decreased AHI although it did not reach 50%. In this study, there was no significant difference between AHI, BMI, and age in each sample so the effects of AHI, BMI, and age can't be seen in this study.[12] From the efficacy perspective of OA against OSA, these two studies have similar results: OA can reduce AHI, which means it is effective for treating OSA.[4,12]

Research conducted by Lu, et al and Nikolopoulo et al in mild and moderate OSA also showed similar results.[2,10] According to research by Lu et al, the use of OA can reduce the AHI by 20.91± 0.56/h, from 27.65±1.31/h to 6.74±0.75/h after therapy. The results from Lu also show that the volume of the palatopharyngeal and glossopharyngeal also increased with the use of OA so the space of oropharyngeal and glossopharyngeal is wider, with this can be seen that OA became effective. Nikolopoulo, in his research also compared the effectiveness of OA against CPAP and placebo and all three showed a good response to treat OSA even though the value obtained using placebo was not as high as OA and CPAP, presumably this could be due to the placebo effect.[2]

Guillaume et al, Byun et al, and Enrique et al. conducted a similar study on moderate and severe OSA, these three researchers also showed similar results regarding the effectiveness of OA against OSA.[7,11,13] Guillaume et al. showed that the use of OA could reduce AHI by 50% in 65.2% of patients, decrease AHI <50% and AHI >10/h in 50.1% of patients, and AHI to <5/h in 26.1% of patients. On the other hand, Guillaume also said that increasing advancement was not significant in reducing AHI.[7] Similar results were obtained from a study conducted by Byun et al, after treatment with OA, AHI was reduced by 63.95%. 31.1% achieved normal AHI <5/h and 64.4% of patients achieved AHI <10/h.[11] According to Guillaume and Byun, the decrease in AHI is also influenced by BMI, the higher a person's BMI, the lower the effectiveness of OA.[7,11] Enrique et al stated that the use of OA has an effectiveness of 63.3%, that is not much different from the study conducted by Guillaume and Byun.[13]

The eight literatures used in this scoping review shows similar results, OA can effectively reduce symptoms in OSA. This remains the same even if the research is evaluated objectively, subjectively, or both. Research conducted subjectively on the literature used was only conducted by Nordin et al,[1] objective study was conducted by Byun et al. and Nikolopoulo et al,[4,7] and the rest used a combination of subjective and objective. [2,10–13]

The difference in AHI reduction in each literature is also different, this is influenced by the classification of OSA and also BMI. In studies conducted on all OSA classifications, whether mild, moderate, or severe, there was an average decrease in AHI of 10/h.[4,12] In studies that only examined mild and moderate OSA, the average decrease in AHI was 20/h, some patients can even almost reach normal AHI with the use of OA.[2,10] In modederate and severe OSA, achieving an almost normal AHI was only achieved by 25-30% of patients, while the rest experienced a decrease in AHI of 50-64.4%. According to Guillaume and Byun, the decrease in AHI is also influenced by BMI, the high-

DOI: 10.46934/ijp.v4i2.246

er a person's BMI, the lower OA effectiveness.[7,11]

It is concluded that OA effectively reduces the symptoms of OSA. It must be noted that objective examination through the AHI evaluation shows that AHI reduction is affected based on the OSA and BMI classification. Patients with high BMI demonstrated a smaller reduction in AHI, thus showing low effectiveness of OA. Considering the limitation of this scoping review, it is suggested that future reviews should be presented with a more uniform study design to reflect more accurate results regarding the efficiency of OA in treating OSA.

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DOI: 10.46934/ijp.v4i2.246

Prosthodontic rehabilitation for maxillofacial defects by mucormycosis post Covid-19 pandemic

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ABSTRACT
Since the outbreak of Covid-19, with every mutation, it has posed various challenges to human life and in health sciences. Patients on corticosteroids or with comorbidities like diabetes mellitus are at increased risk of post Covid-19 infections like mucormycosis. Mucormycosis is a rare opportunistic infection, often associated with immunocompromised states. Fungal invasion of the hard palate, paranasal sinuses, orbits and brain is the commonest form of rhinocerebral mucormycosis. Among the medical professionals involved in managing patients with mucormycosis, maxillofacial prosthodontists are responsible for prosthetic treatment of lost oral and maxillofacial structures, helping patients to socialize and have an acceptable quality of life after surgical treatment. This literature review is aimed to describe maxillofacial prosthodontist challenge in rehabilitation of mucormycosis post Covid-19 infection. It is concluded that prosthodontist face many challenges in mucormycosis rehabilitation. Prosthodontist should be capable to early detection and diagnosis, carefull in planning and designing the prosthesis, wise in using of softliner material, and should always maintain long-term follow-up if any sign of lesion recurrence.
Keywords: mucormycosis, Covid-19 pandemic, maxillofacial rehabilitation

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 or (SARS-CoV2) has been declared in 6th Public Health Emergency of International Concern (PHEIC).[1] Since the outbreak of Covid-19, various mutations have occured and posed various challenges especially in health sciences. Coinfection and superinfection are common in any viral infection. Coinfection happens simultaneously, while superinfection develops after initial infection.[2] Mucormycosis is the third most common opportunistic infection after candidiasis and aspergillosis.[3] Covid-19 patients with diabetic ketoacidosis, cancer, organ transplant, neutropenia, corticosteroid usage, and hemochromatosis were predisposition factor to mucormycosis.[4]

The prevalence of mucormycosis is nearly 80 times higher in India than in developed countries.[5] Mucormycosis found in tropical and subtropical climates, such as Indonesia. Indonesia is a tropical country, warm and humid, which provides a good environment for fungi growth. Unfortunately, the prevalence of mucormycosis in some developing countries, including Indonesia, are still unclear because the cases remain undiagnosed due to difficulty in collecting tissue samples and limited facilities of mycology laboratories.[6]

Maxillofacial prosthodontist is a medical professional which involved in managing patients with mucormycosis, responsible for prosthetic restoration of lost structures in oral and maxillofacial, helping patients to socialize and have an acceptable quality of life after surgical treatment.[7] Some of the problems associated with rehabilitating extensive intraoral defects make it extremely challenging for a prosthodontist to fabricate a prosthesis. The expected outcomes are an improvement in the overall function and aesthetics after the insertion.

The purpose of this review is to describe maxillofacial prosthodontist challenges in rehabilitation of mucormycosis post Covid-19 infection.

LITERATURE STUDIES

Mucormycosis

According to WHO, mucormycosis, sometimes called zygomycosis, is a serious fungal infection but rare, caused by a group of fungi called mucormycetes.[8] Mucormycosis is a non-contagious yet aggressive and life-threatening infection. Mucormycosis mainly affects immunocompromised patients, or patients already infected with other diseases. Higher risk groups include people with diabetes (especially diabetic ketoacidosis), solid organ transplantation, neutropenia (low neutrophils, a type of white blood cells), long-term systemic corticosteroid use, and iron overload (hemochromatosis).[2,9,10] Patients on corticosteroids or with comorbidities like DM are higher risk of post-Covid infecfections like mucormycosis.[11,12]

Globally, prevalence of mucormycosis ranges 0.005-1.7 per million people. The etiologic agents mostly are *Rhizopus* spp, *Mucor* spp, and *Lichtheimia* (formerly *Absidia* and *Mycocladus*) spp.[5] Several recommendations for clinical management

DOI: 10.46934/ijp.v4i2.247

and diagnosis of Covid-19 associated mucormycosis are similar to non-Covid-19 patients.[13] The Prevention of Covid-19 associated mucormycosis needs to focus on better glycemic control and monitoring the use of systemic corticosteroids/other immunomodulating drugs in treating severe cases.[14]

Clinical manifestations of mucormycosis

The clinical features of mucormycosis depending on infection site. Generally, infection starts in the oral cavity or nose and travels to the central nervous system through the eyes.[15] Among the various clinical forms of mucormycosis, rhinocerebral is the common one, accounting for one third to half of the reported cases. It is further divided as rhino-orbitalcerebral type-1 more fatal and rhinomaxillary form type-2 less fatal, involving ophthalmic with internal carotid arteries and sphenopalatine with greater palatine arteries respectively.[16,17]

Ahmed et al, described oral signs of mucormycosis are often evident in the palate and may include varied degrees of mucosal staining, swelling, ulcerations, superficial necrotic regions in palatal, bone exposure, and necrosis with black eschar development.[18] Palatal ulcerations may be the first presenting symptom, demanding the patient to seek treatment. Dentist is the first clinician to identify an infection, leading to the diagnosis of mucormycosis posibilities.[19]

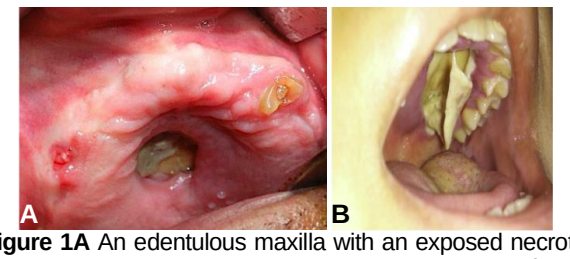

Figure 1A An edentulous maxilla with an exposed necrotic bone in palate and draining sinus in right canine region.[18] **B** ulcers in palate of mucormycosis patients.[10]

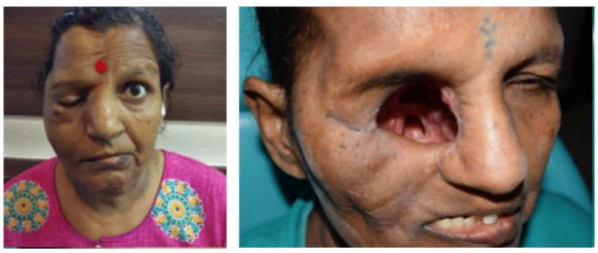

Figure 2 Sino-orbital mucormycosis.[23]

In patients with poorly regulated diabetes, dental procedures can be a risk factor for rhino-orbital cerebral mucormycosis.[20] Dental infections can lead to destructive infections of the mandible or maxilla. Headache, fever, nasal inflammation, facial pain, palatine mucosa ulceration, or dark nasal and periorbital swelling are some of the signs and symptoms of the problem.[20,21] Cellulitis, chemosis, proptosis, and blurred vision are all signs of orbital invasion.[21] Intracranial progression through direct extension or angioinvasion can happen quickly, within days. A high mortality rate is linked to brain involvement (Fig.1, Fig.2).[22]

Clinical diagnosis

An identification of host variables, quick evaluation of clinical symptoms, and a strong index of suspicion are required for diagnosis of mucormycosis. Pleuritic discomfort in a neutropenic patient or diplopia in a diabetic patient are the symptoms of mucormycosis infection that prompt the use of diagnostic imaging techniques and sample testing by microbiology, histology, and molecular modalities.[23] Other funguses such as *Fusarium* or *Aspergillus*, can cause similar clinical symptoms.[24]

Corzo-Leon et al, devised a method for detecting *rhino-orbital cerebral mucormycosis* in diabetic individuals. The following clinical manifestations must be regarded *red flags* which includes diplopia, proptosis, sinus discomfort, periorbital edema, cranial nerve palsy, palatal ulcers, and orbital apex syndrome.[25] Since the signs and symptoms are not specific, dental practitioners should be cautious if a patient has a history of COVID-19 infection, administered high-dose systemic steroids, broad anti-microbials and mechanical ventilation with any of these red-flags signs and symptoms. [17,23]

Prosthodontic considerations

The post-surgical defects of mucormycosis are remarkably different from the defects that result from tumor resection due to the unpredictable, indefinable advancement of the fungus and the probable requirement of additional debridement procedure.[17] In tumor cases, surgical modifications can be done in favour of prosthetic rehabilitation but cannot be accomplished in mucormycosis cases.[26] Therefore, provision of prosthodontic rehabilitation is worsened in mucormycosis patients especially edentulous, the resultant defect cannot be used effectively to retain, support, or stabilize the obturator prosthesis and these defects are poor in stress-bearing surface.[20,22]

The classification of maxillary defects by Durrani et al seems appropriate to correlate with the clinical stages of mucormycosis.[27] The classification is alveolectomy where the defects involve the alveolar bone alone, sub-total maxillectomy these defects cause oronasal or oro-antral fistula but do not disturb the orbital wall of maxilla, total maxillec-

DOI: 10.46934/ijp.v4i2.247

tomy these defects are characterized by absence of complete maxilla including orbital floor but the orbital contents remain intact, radical maxillectomy these defects are characterized by absence of orbital contents along with the maxilla and the last composite maxillectomy defects involve resection of facial skin, soft palate, and other part of the oral cavity.[27,28] All these defects can be further classified into unilateral and bilateral defects.

Prosthodontic treatment for mucormycosis

Prosthodontic therapy for patients with acquired surgical defect are rehabilitated in three phases through different stages of healing. The phases of treatment are arbitrarily divided as follows; surgical obturation, interim obturation and definitive obturation.[27] Immediate surgical obturation grants the placement of prosthesis immediately after surgery. It is retained about six days post-surgery.[23] The obturator acts as surgical dressing. It also decreases contamination of the wound, helps in deglutition, permitting early removal of nasogastric tube. The outline of surgical margins is discussed by maxillofacial surgeon and prosthodontist before the prosthesis is fabricated.[29]

Planning of surgical margin is not be always possible especially in mucormycosis cases since it is rapidly progressive.[30] Nevertheless, a delayed surgical obturator can be planned in situations where it necessitates emergency surgical debridement which would be a lifesaving action, and also in cases where a prosthodontist could not be consulted beforehand. It could also be considered in cases where there is requirement of additional debridement procedure due to indefinable advancement of the fungus.[31]

Interim obturator is advised in cases with large defects, where appropriate function and comfort cannot be maintained until fabrication of new prosthesis. The surgical and definitive obturators are intervened by interim obturator.[29] Fabrication of definitive prosthesis cannot be considered till the surgical site is healed, dimensionally stable and most importantly, until the patient's systemic condition becomes stable, specifically in rhinocerebral mucormycosis, which has a high chance of recurrence and high mortality rate even after treatment.[32]

Definitive obturator is commonly indicated three months after surgery. The factors such as the state of healing, dimension of the defect, effectiveness of previous obturator and the remaining teeth must be considered in construct a definitive obturator.[29] In addition, the prognosis of the fungal infection along with the systemic condition of the patient must be determined.[23] The dimensional changes occurring due to structuring of the wound and scar contracture is extended for one year and fundamentally related to the lining soft tissues rather than the underlying bony area, thereby needing periodic follow up.[28,32]

Implants

Osseointegrated endosseous and maxillofacial implant such as zygomatic and pterygoid implants have dramatically raised the potential for reconstruction of patients with varied soft and hard tissue maxillofacial defects. Implants contribute in retention, support and enhance the stability of prosthesis.[26] Furthermore, placement of implants with surgical reconstruction of extensive hard tissue defects facilitates prosthodontic rehabilitation with fixed prosthesis. The decision to place implants or not should always be evaluated specifically in mucormycosis patients due to systemically immunocompromised.[29,32]

DISCUSSION

SARS-CoV-2 can infect and replicate in the human islet cells, leading to β-cell damage and reduced endogenous insulin secretion.[33] Diabetes mellitus being a major risk factor for mucormycosis. John et al, identified 41 confirmed cases in patients with Covid-19 and noted that 93% had diabetes and 88% were receiving corticosteroids.[34] Another indirect association between the concomitant surge in Covid-19 and mucormycosis is the dissemination of fungal spores via water used in oxygen humidifiers.[14,35] The most commonly affected site was the nose and sinuses (88.9%), which is followed by rhino-orbital mucormycosis (56.7%) and rhino-orbital-cerebral mucormycosis (22.2%).[9]

Early and complete surgical treatment is recommended for mucormycosis, besides antifungal medications and correction of predisposing factors.[28] Increasing number of cases and predominant involvement of the orofacial region, can expected to encounter more patients with orofacial defects after surgical treatment of mucormycosis post Covid-19 pandemic.[7,31] Hence, there is an urgent need to provide maxillofacial prosthetic rehabilitation for patients with mucormycosis to improve their quality of life.[7] Increased awareness of morbidity is needed among medical professionals.[10,28,36]

Prosthodontist face many challenges in mucormycosis rehabilitation, not only to replace the missing teeth, but also the lost soft tissues and bone, including hard palate and alveolar ridges. Prosthodontist should be capable to early detection and

DOI: 10.46934/ijp.v4i2.247

diagnosis. Before beginning treatment for mucormycosis, the patient should be assessed by a medical specialist, ideally an endocrinologist, to ensure adequate protection with long-acting insulin and a systemic antifungal to prevent future fungal infection during and after treatment.[10] Severe ulcerative ulcers should be considered as mucormycosis, especially in post-covid patients with diabetes. Patients who have recently recovered from Covid-19 infection should be monitored carefully, regardless of whether they have a history of mucormycosis, and should be well-sterilized before delivery, especially if an immediate surgical obturator is used, because it will be contact with an open wound.[9,34] Any symptom of sinusitis should be done radiographic diagnosis.[24] Severe ulcerative ulcers, visual disturbance, or facial or orbital swelling should be considered as mucormycosis, especially in post-covid patients with diabetes.[2]

Prosthodontists have a role to determine the types of prosthetic rehabilitation needed after surgical treatment of mucormycosis and site specificity.[29] Immunocompromised states may be associated with the occurrence of mucormycosis.[7,37] The prosthesis obturators with poor bony and structures in posterior palatal seal area were dangerous retention of the prosthesis. Post surgical soft tissues are scarred and tense, exert strong dislodging forces. The prosthesis that replaces all of the missing structures will necessarily be bulky, added weight and volume also complicates retention of prosthesis.[28]

Prosthodontist should be careful in planning and designing of the prosthesis. The principles of prosthetic management are simple and fundamental.[7] Prosthesis design is varying with the type and expansion of the defect.[11] A prosthesis that can be easily removed has advantageous in checking for the recurrence of infection at surgery site, which could help in early diagnosis and treatment before complications develop.[35] Advanced treatment with implant is less reported in litera-ture.[9,38] It can be caused of fewer prevalence of the disease in past years. The use of implant and other options is planned with fundamental principles that can help in improving the quality of life of patients.[37]

Complex maxillofacial defect needs rehabilitation with obturator combine with orbital prosthesis.[10] In such cases achieving optimum retention for the orbital prosthesis is a challenge and usually retained by retentive attachment fixed to bulb of the obturator with magnets or buttons.[10,21] Due to absence of infraorbital bone, the obturator lacks in vertical support and stability. Attached orbital prosthesis tends to move during mastication.[23] The challenges in sino-orbital case were to achieve retention for orbital prosthesis from bulb portion obturator and passivity of retentive attachment between obturator and orbital prosthesis so movement of orbital prosthesis could be minimised during function.[17]

Large-sized maxillectomy defects often result after surgical treatment of mucormycosis, and the duration of healing is determined by the aggressiveness and postoperative care.[36] A lighter obturator improves suspension cantilever mechanics, prevents overstressing of the remaining supporting structures, and increases retention.[10,39] The open-hollow bulb design is also preferred over the closed-bulb design because it is lighter in weight, easier to fabricate, and produces noticeably better articulation.[39] Regular follow-up tends to accumulate mucous secretions, which can be a source of infection.[37] Remote implant-bone anchorage using pterygoid, zygomatic, and nazalus implants was also reported to be a more effective solution than conventional implants in improving prosthesis retention and support.[7]

Unlike other disease/defects, the choice of surgical planning for prosthesis is limited in mucormycosis.[39] The rehabilitation treatment is done after complete recovery from infection. The stability of the tissues is assessed, and prosthesis design is decided on the functional requirements.[39] Majorly nonkeratinized mucosa is observed in the defect areas, it can complicate postoperative care and prosthesis retention. The use of skin grafts or protection of raw tissues with keratinized mucosa can be supportive.[2,5]

Surgically resected cases have immediate or delayed surgical obturators without soft liners.[24,26] If soft materials such as resilient liners are used on the fitting surface of the obturator, frequent cleaning is recommended because higher risk of fungal contamination.[31] The use of soft liners in a definitive obturator has advantage of reducing pressure on defect areas by providing a cushioning effect between the prosthesis and the defect margins.[10] In addition, the flexibility of these materials allows for easier placement of the obturator into retentive undercuts.[31] However, in a patient with a history of mucormycosis, the use of soft liners in a prosthesis that contacts the nasal mucosa is not recommended.[6] This is due to their higher risk of fungal contamination compared to acrylic resins.[13]

Maxillofacial prosthodontist should always maintain long-term follow-up and visual examination for any signs of lesion recurrence.[10,18] It is crucially

DOI: 10.46934/ijp.v4i2.247

important to keep in mind that maxillectomy defects are always prone to bacterial superinfection by oral and respiratory commensals.[10] Even in rehabilitation period, a superinfection can still occur. Combined with the risk of recurrence of the primary mycosis, patients should be scheduled for long-term follow-up appointments.[31]

Proper instructions were explained about denture hygiene, placement, and removal. Disinfection of acrylic partial or complete dentures can be achieved by soaking in a denture cleanser or 0.5% solution of sodium hypochlorite (1:10 ratio with water) for 10 min.[40] In denture-related mucormycosis cases, the patients should be guided to microcrowave disinfection of acrylic-based dentures, once per week. Microwave disinfection is as effective as 14-days topical antifungal medication.[24,41] Metal denture disinfection is minimal published reports. The literature guides that metal-based dentures should be disinfected using chlorhexidine, hydrogen peroxide, and antifungal solutions.[40]

Important to follow various guidelines related to the oral health post covid-19 pandemic. These include: regular brushing twice a day with flossing and mouthwash with 1% povidone iodine, monitoring blood glucose levels for glycaemic control in diabetics, monitoring of the mucosal changes in patients wearing removable or fixed prosthesis, high protein and low sugar diet with multivitamins are advised.[40,41] Dentures are cleaned properly with tooth brush and gauze pieces. Furthermore, it is recommended to change the toothbrush in patients recovered from COVID-19. [40]

It is concluded that prosthodontist face many challenges in mucormycosis rehabilitation. Prosthodontist should be capable in early detection and diagnosis, carefull in planning and designing the prosthesis, wise in uses of softliner material, and should always maintain long-term follow-up if any sign of lession recurence.

It is suggested that increasing number of mucormycosis cases post Covid-19 is an urgent need to raise awareness. Prosthodontists need to share their experiences in prosthetic rehabilitation of mucormycosis by publication so the prosthodontist can confront the challenges together.

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DOI: 10.46934/ijp.v4i2.247

Stress distribution evaluation of complete denture with soft denture liners in knife-edge alveolar ridge using finite element analysis

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ABSTRACT
Edentulous induces the function of the stomatognathic system particularly masticatory performance. The consequence that occurs in complete edentulous is the resorption of residual ridge and can alter the morphology of alveolar bone gradually from well-rounded to knife-edge ridge form. Excessive occlusal load absorbed by the knife-edge alveolar ridge when the denture is exposed to masticatory loads enhances ridge resorption and more complex treatments are needed in manufacturing complete dentures (CD). Soft denture liners (SDL) overcome CD problems with knife-edge ridges by utilizing the cushioning effect by distributing the load evenly to the alveolar ridge. The most popular method used today to evaluate the stress distribution at the alveolar ridge is *finite element analysis* (FEA) because it presents information in both qualitative and quantitative forms. This study is aimed to evaluate the differences in stress distribution received by knife-edge ridges in CD with SDL. Denture base applied with acrylic soft denture liner (ASDL) and silicone soft denture liner (SSDL). It is concluded that ASDL provides a better stress distribution than SSDL because of its viscoelasticity, while SSDL is superior in terms of durability.
Keywords: complete denture, knife-edge ridge, stress distribution, soft denture liner, finite element analysis

INTRODUCTION

Stomatognathism is a system consisting of dynamic structures (masticatory, supra and infrahyoid muscles and tongue, lips and cheek muscles) and static structures (mandible, maxilla, dental arches, TMJs and hyoid bone) that perform together to control stomatognathic functions especially mastication performance. The efficiency of mastication performance requires a balance between dynamic and static structures of stomatognathic system. Loss of teeth can cause changes in the structure of the stomatognathic system.[1]

An unavoidable consequences of tooth loss, affecting the morphology of ridge if occurs rapidly and continually.[2] Remodeling activity after tooth extraction occurs especially in the crestal residual ridge area, not only reducing bone height but also creating 3-D residual ridge form. Residual alveolar crest crest flattens if bone resorption is greater. When ridge resorption is particularly active at the buccal and or lingual areas, the residual alveolar bone may become a knife-edge shape.[3]

The most common treatment for edentulousness is still complete denture (CD).[4] CD treatment in knife-edge ridge is more complex.[5] In prosthetic area, bone is considered to be the base which provides support for dentures while in the physiological area, it is an area where forces created while biting and chewing foods are transmitted.[6] Discomfort is the most problem to denture patients with knife-edge ridge.[7]

Relining CD with SDL is treatment of choice for knife-edge ridge; SDL properties is cushion effect can minimizing denture bearing area's load by distributing the masticatory forces transmitted to the underlying tissue to prevent severed bone resorption.[7] Using the best SDL material still arouse some discussion. The commonly SDL used nowadays is plasticized acrylic and silicone [8] Acrylic soft denture liner (ASDL) demonstrate viscoelastic behaviour, distributing occlusal load transmitted to the underlying tissue, meanwhile silicone soft denture liner (SSDL) demonstrate elastic behaviour, preserve their shape despite the applied pressure upon them.[9] SDL is a material that can be used for residual ridge resorption cases.[8] Several methodologies have been used to help assess stress distribution in dentures wearers such as photoelastic models, analytical mathematical models, use of strain gauges and finite element analysis (FEA). First three methods provides only provide limited data while FEA is capable of providing detailed quantitative and qualitative data.[10]

The FEA provide noninvasive technology that provide qualitative and quantitative information of biomechanical characteristic of dental prosthesis and supporting structures for assessing occlusal load to the underlying tissue.[11,12] This method expected to evaluate stress distribution of CD with SDL in knife-edge ridge.

LITERATURE STUDIES

Edentulous

Full edentulous has a high prevalence globally and affects 0.1–14.5% of people under the age of 50 and 2.1–32.3% of the elderly worldwide.[13,14]

DOI: 10.46934/ijp.v4i2.248

Progressive residual alveolar ridge remodeling will occurs rapidly especially in the first year after tooth extraction on edentulous patient in the mandible than maxilla, with the mean rate of resorption varying depending on the individual.[5] If bone resorption is emphasized at the crest of the residual alveolar bone, it becomes flattened. When the resorption is more active at the buccal and/or lingual areas, the residual alveolar bone tends to become thin and sharp or known as a knife-edge ridge,[3] where the mucosa is squeezed between the sharp ridge and the denture resulting patient's pain and discomfort.[15]

The masticatory force of the edentulus is only ¼ of that normal mastication. The CD wearers will change in mastication associated with increased mastication cycles, longer mastication times and decreased mastication averages. To overcome this, the prosthetic treatment of choice for a long time has been CD with the aim of rehabilitating edentulous patients in order to improve comfort, aesthetics, occlusal and facial support, masticatory function and pronunciation.[13]

Knife-edge ridge

Knife-edge ridge is a localized phenomenon that occurs in the buccal or lingual area of residual alveolar bone due to continuous osteoclast activity.[3]

Classification of residual ridge resorption according to Atwood (Fig.1): order 1 is pre-extraction, order 2 is post extraction, order 3 is high, well-rounded, order 4 is knife-edged, order 5 is low, well rounded, and order 6 is depressed[16,17]

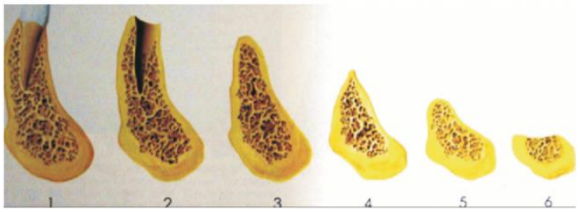

Figure 1 I (pre-extraction), II (post extraction), III (high, well-rounded), IV (knife-edged), V (low, well rounded), VI (depressed).[17]

Knife-edge ridges require surgical treatment but if the patient's condition is not possible, SDL can be applied to improved masticatory function of the denture.[14]

Soft denture liner

Soft denture liner (SDL) is a material that form a cushioning layer between the denture base and the underlying mucosa;[7] SDL is indicated in knife-edge ridges cases, large ridge resorption, severe bony undercuts, chronic soft tissue inflammation and relining immediate dentures.[9,18] The advantages of using SDL is its flexibility and resilience, provide a *cushion effect* that can absorb stress and function as a *shock absorber*[5,14] as well as provide *chewing-wing satisfaction*.[19]

Based on term usage, SDL is divided into short-term SDL and long-term SDL. Short-term SDL is known as tissue conditioner while long-term SDL is also called semi-permanent reline materials. Based on the composition, long-term SDL is divided into acrylic soft denture liner (ASDL) and silicon soft denture liner (SSDL) which are available in auto-polymerized and heat-polymerized forms. ASDL auto-polymerized include *Permasoft, Flexacryl* while heat-polymerized include *EverSoft, Super-Soft*. Auto-polymerized SSDL include *Mollosil Plus*, *Tokuyama Soft* while heat-polymerized include *Molloplast B, Permaflex Luci-Soft*.[12,20]

The ASDL has material properties of viscoelastic behavior while SSDL shows material properties of elastic behavior. Viscoelasticity is a material property that provides both viscous and elastic properties, in other words when the applied pressure is removed, there will be elastic deformation (back to its original shape) which will increase the contact surface with the denture so that the stress distribution is more even and if the pressure is not removed for a long time, there will be plastic deformation (changes in shape).[21,22] ASDL has good adhesion to the denture base but over time due to plasticizers (components that make acrylic softer) easily dissolve, SDL will harden and lose its *cushion effect* while SSDL will last for a longer time.[7] SDL thickness also plays an important role in stress distribution, especially in patients with thin mucosal conditions.[23]

Widely used method to evaluate the stress distribution is FEA because it can simulate the FE model as closely as possible to the original condition.[11] FEA is able to provide quantitative data on all area so it's needed in dentistry. The advantage of FEA is its ability to analyze various forms, loads, and supporting conditions so that it allows the application of forces or stresses at various points in various directions.[10]

Finite element analysis

Finite element analysis (FEA) is a non-invasive technology that produces qualitative and quantitative information on the biomechanical characteristics of dental prostheses and their supporting structures that can analyze masticatory loads under denture bases.[11,12]

Application of FEA by constructing a finite element (FE) model(s), by recording specific material properties, loads and special conditions to get an

DOI: 10.46934/ijp.v4i2.248

accurate simulation. With the development of digital imaging systems, FEA can be performed on the human body through the transfer of geometry data and bone properties in 3-D form from cone beam computerized tomography (CBCT) or magnetic resonance imaging (MRI) to the FE model so that the model is anatomically accurate and the simulation carried out can be conditioned as the original.[11]

DISCUSSION

The SDL is one of the solutions to overcome complaints about discomfort, instability and lack of retention on CD wearers. A recent study was conducted to compare the effect of using CD before and after the addition of SDL on mastication performance and the results showed a significant increase in mastication performance after the addition of SDL. SDL is effective in increasing stress distribution for CD wearers with knife-edge ridges.[5] Based on literature, the use of SDL can reduce the occlusal load received by the alveolar ridge so that will decrease the resorption due to the cushioning effect produced by the SDL.[15]

In 2016, Singh et al stated that the use of SDL on knife-edge ridges can balance the occlusal load received by the supporting tissues under the denture base.[24] In theory, ideally SDL should have elastic behavior to transmit the energy needed in the mastication system and have viscous properties to distribute the force, absorb energy and avoid pain during mastication, providing cushioning effect to prevent the transmission of load to the denture bearing area.[25] Kreve et al stated that viscoelastic properties played a role in stress distribution and absorption during clinical function.[26]

Shrivastava et al based on their research showed that ASDL have a higher average stress relaxation than SSDL. Clinically, almost all patients who were research subjects were satisfied with the use of ASDL rather than SSDL, possibly due to the viscoelastic behavior of ASDL.[27,28] The same thing was also stated by Salloum, quoted from Taguchi et al, in his research which stated that ASDL showed a higher average stress relaxation than SSDL and is related to the viscoelastic properties demonstrated by ASDL while SSDL shows more elastic properties.[29] That statement is also supported by Murata et al, who stated that the clinical success of an SDL material depends on its viscoelasticity and durability. Viscoelasticity greatly affects the *cushion ef-fect* of SDLwhich is owned by ASDL while SSDL is superior in terms of durability observed over a 3-year period.[28]

On the other hand, Husein stated that the use of SSDL showed a better stress distribution than ASDL and this was also confirmed by Radi et al who stated that the stress distribution analyzed using FEA showed a stress distribution decrease up to 73% when ASDL was replaced by SSDL.[30] A clinical study conducted by Abdelnabi et al in 2020 also concluded that the addition of SSDL to the CD base provided better masticatory performance than ASDL after 3 months of use, indicating that SSDL has better long-term results.[31]

Differences of opinion in some literature may be due to the *cushion effect* of SDL related to length of use, the short time period of the study and the material behavior of SDL.

It is concluded that the stress distribution of CD in knife-edge ridge with the addition of ASDL is better than SSDL when evaluated using FEA because of its greater viscoelasticity while SSDL is superior in terms of durability.

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